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EDITORIAL NOTES.

THE Council of the Geological Society has this year made the following awards: Wollaston Medal (in duplicate), Dr. John Horne, F.R.S., and Dr. B. N. Peach, F.R.S.; Murchison Medal, Mr. E. S. Cobbold; Lyell Medal, Dr. E. de Margerie, Director of the Geological Survey of Alsace-Lorraine; Bigsby Medal, Dr. L. L. Fermor, Geological Survey of India; Wollaston Fund, Dr. T. O. Bosworth; Murchison Fund, Dr. A. Gilligan, University of Leeds; Lyell Fund, Professor H. L. Hawkins, University College, Reading, and Mr. C. E. N. Bromehead, H.M. Geological Survey.

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THE following eminent geologists have been elected Foreign Members of the Geological Society: Dr. F. W. Clarke, Washington (D.C.), U.S.A.; Professor E. Haug, University of Paris; Professor M. Lugeon, University of Lausanne; Professor H. Schardt, University of Zürich; Dr. J. J. Sederholm, Director of the Geological Survey of Finland; and Dr. H. S. Washington, Geophysical Laboratory, Washington (D.C.), U.S.A. At the same time Foreign Correspondents were elected as follows: Professor L. Cayeux, Paris; Dr. M. Cossmann, Paris; Professor H. de Dorlodot, Louvain; Dr. H. Douvillé, Paris; Professor L. Duparc, Geneva; Professor J. Kjaer, Kristiania; Professor W. Lindgren, Boston; Professor J. J. Stevenson, New York.

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THE science of mineralogy has suffered a severe blow by the death on January 6 last of Sir Lazarus Fletcher at Grange-over-Sands, where he went to reside on his retirement from the Natural History Museum less than two years ago. A memoir and appreciation of his work will appear in our next number.

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THE Council of the Geologists' Association has this year presented the Foulerton Award to Mr. Llewellyn Treacher, F.G.S., who has been an active member of the Association for twenty years, and has conducted numerous excursions to places of interest in Berkshire and Oxfordshire, which counties have been the scene of the greater part of his original work.

ORIGINAL ARTICLES.

The Glaciation of Ireland.

By Percy F. Kendall.

DURING the year 1920 two contributions on the subject of Irish Glacial Geology have appeared, differing greatly in scope and treatment. Mr. Wright's paper on "Minor Periodicity in Glacial Retreat" is frankly speculative, but his speculations are based upon an accurate and fairly exhaustive survey of the glacial evidences in the country about the head of Kenmare River, the deep ria lying between Bantry Bay, Dingle Bay, and the lake region of Killarney.

The phenomena of which an interpretation is attempted belong to a late stage of the glaciation of the West of Ireland when the ice had shrunk back from the central plain and was apparently reduced to a series of independent systems of glaciers radiating from centres only a few miles from the seaward ends of certain of the rias.

Of all the other districts that have been studied none seems so remarkable and anomalous as this. The author shows by a map (fig. 1) the direction of ice-flow, from which it appears that the radiant point whence the ice flowed in every direction was not, as might have been expected, the lofty hill cluster of Macgillicuddy's Reeks culminating in Carrantuohill, 3,414 feet high, but either in the bed of the ria itself or in the low hills 1,100 to 1,300 feet high that lie along its northern shore. From this centre the passes through the Reeks were over-ridden, only the higher summits rising as nunataks above the ice.

The cause of this astonishing phenomenon has never been discussed—perhaps not even considered—but it is to be hoped that light will be thrown on the problem in the promised general memoir on Kerry. No doubt the mere fact that the last remnants of the great ice-sheet lingered in the west finds a ready explanation in the present meteorological conditions, the mountainous margin inducing copious precipitation; the problem is, however, to explain why, with a broad valley opening directly upon the coast and a dwindling mountainous margin on each side, the discharge should have taken these inland courses instead of flowing freely into the Atlantic. The temptation to invoke differential earth movement is checked by the reflection that lake-terraces extending for 12 miles "show no departure from horizontality which is not included within the limits of error inseparable from such observations of level as it has been found possible to make".

Mr. Wright describes this lake that occupied the upper part of the Kenmare Valley in considerable detail. It was held up by the ice to the level of the col at Morley's Bridge 320 feet O.D., and at this

level on both sides of the valley extends a beach rivalling the famous Parallel Roads of Glen Roy.

The materials of the beaches were, according to the author, supplied by marginal streams flowing along the edge of the ice, and for this reason a tributary valley has developed a terrace only on the west, that is the ice-ward, side.

The phenomena to which the title refers are a series of crescentic moraines—gravelly or sandy where below the lake-level, mainly clayey above. These occur on two scales of magnitude—larger moraines at intervals of about a mile and, above the lake-level, minor ridges at intervals of 50 to 100 yards. Mr. Wright ventures the suggestion that these correspond respectively to Brückner's thirty-year cycle of glacial fluctuations in the Alps and to the annual retreats established by de Geer's study of the nodes in the eskers studied by him in connexion with his seasonal clays, two layers of the clay representing a year's retreat. Mr. Wright finds confirmation of this view in the successive knobs of an esker close to Kenmare. The esker is about 600 yards long, and contains seven or eight of these hillocks. "The rate of retreat thus indicated is about 80 yards per annum."

The author applies similar methods to the great morainic amphitheatres near Killarney and Killorglin, from which he draws analogous deductions.

While the generalizations of the author of this paper may strike some as being rather too bold, it must be borne in mind that Glacial Geology has gone far beyond the stage when mere accumulation of undigested and unrelated facts should be recorded, and whether the time estimates suggested by Mr. Wright are accepted or not, he has indicated to British geologists a new method of inquiry that will certainly yield results of great interest and importance.

Of Professor Gregory's paper entitled "The Irish Eskers",[1] it is difficult to express my exact sentiments, for, despite the dignity of the *Philosophical Transactions* quarto, I feel that it does less than justice to the subject, to the author's position as a geologist, and to the large public to which his writings appeal. Of new field observations there are very few, and those few are susceptible of other interpretations than those the author puts upon them. The citations of the literature of British Glacial Geology are almost confined to a bygone generation; and the illustrations, where original, rarely exhibit features that are truly diagnostic, while in more than one instance the text is directly contradictory of the figure. The proposition which the author sets out to establish is that, contrary to the opinion expressed by Professor Sollas in his well-known memoir, the Irish eskers are mainly marginal—a species of well-washed bank laid down parallel to the edge of a dwindling ice-sheet that terminated in a rather shallow sea. Others he regards as the

[1] *Phil. Trans.*, ser. B, vol. ccx, pp. 115-51.

products of glacial rivers, but he combats the opinion that they were laid down either beneath the ice or in ice cañons. Some arguments are advanced which will perhaps be accepted as sound, but, before Professor Gregory's views can be generally adopted, I feel that the subject must be approached with much greater deliberation and with a much fuller knowledge both of the facts already recorded and of Irish geology than he at present possesses.

It is obvious, as the author himself remarks, that "The first test, whether the eskers were due to sub-glacial rivers or were deposited as marginal banks, is the sources of the esker materials", yet he has made no attempt whatever to accumulate this vital evidence beyond a very few casual references; nor has he even used the data already provided by the Geological Survey and by other workers. In some instances these would support his conclusions, but in others they are in entire contradiction; for example, the ridge near Barony Bridge is thus alluded to by him under the heading "The Eskers of Tyrone": "has obviously been formed as a marginal formation by a glacier flowing northward and north-westward from Evishanoran Mountain." Dr. J. K. Charlesworth, on the other hand, informs me that the ridge in question was certainly laid down by ice moving *from* the north-west, and that it is full of the Tyrone granites.

In another case I think Dr. Gregory is right in spite of himself; his fig. 9 is a map showing the Esker System near Dunmore, co. Galway. Of this he says: "The distribution of the erratics, the direction of the striæ, and the trend of the drumlins show the main flow of the ice was from north-west to south-east." Now, the only mention of erratics is a casual reference to black chert, which has no bearing on the question, as it might have come from any point of the compass; no information whatever is vouchsafed regarding the drumlins, and it is amazing, but true, that the striæ are indicated on the maps by arrows "after Sollas" which show "the course of the ice-movement" to be, as Sollas explicitly declares, "from south-east to north-west"!

Another, and in many respects more serious, defect is exhibited by a sketch-map (fig. 11), in which "the broken arrows represent the course of the ice-movement after W. B. Wright". The first objection to this is that Wright's fig. 27 in his valuable *Quaternary Ice Age* shows "the lines of ice-flow and limits of glaciation in the British Isles" obviously, by the words just quoted, *at the maximum*, and therefore quite inapplicable to the late stage of shrinkage and retreat represented in Professor Gregory's view by the eskers. But, worse than this, a minute sketch-map one inch in breadth is enlarged up to the full breadth of a quarto page; and, worse still, the enlargement has been so badly done by the artist that arrows have been swung round through angles of 20–40 degrees. This carelessness or unskilfulness might in some cases have been immaterial, but as, for instance, an arrow passing through Carrick-

on-Shannon is made to swerve round the *west* side of the Slieve Bloom Mountains, instead of, as Wright represented it, down the *east* side near the famous Maryboro esker, the error is perhaps accountable for Professor Gregory's mistaken supposition that this esker was "probably formed by ice which flowed down the northern slopes of the Slieve Bloom Mountains". He might have been spared this mistake had he consulted the Geological Survey memoir explanatory of Sheets 117–18 of the year 1866, which states that boulders of the Galway granite "are not so large or abundant on the northern as on the southern slopes of the Slieve Bloom Mountains". The Roscrea esker is by Professor Gregory included in the same explanation, but unfortunately it is not at the northern end of the mountains but a few miles south-west of the southern end.

Professor Gregory insists that the eskers were formed under water, and he assigns an arbitrary limit of 400 feet as the water-line, though in order to do this he finds it necessary without other apparent justification to put the Tyrone ridges in a separate category.

The question whether this was lake or sea he decides in favour of the sea, remarking: "The difficulty in the assumption of a glacial lake is to account for the containing barriers." Without labouring the point, I would say that the interpretation of Irish glacial geology adopted by all recent workers, except Professor Gregory, would without much difficulty provide him with the barriers he would need.

Having settled the marine origin of the eskers the author proceeds to disclose a remarkable and hitherto unsuspected change of opinion on the part of the British glacial geologists. He says (p. 145), "Some submergence of the British area during Glacial times is now generally accepted." Again, on p. 148, "It is now generally agreed that large parts of the British area were submerged in Glacial times to a sufficient height to have flooded the typical esker district of Central Ireland." And finally, with still greater courage, "Boulder-clay, the marine origin of which has been persistently maintained in spite of the rejection of that view by, at one time, the great majority of British glacial geologists." The implications here, and especially in the last quotation, are that a great and hitherto undisclosed revulsion of opinion has taken place, and that in common with the author, who has been sound throughout, the great majority of British glacial geologists no longer reject the marine origin of boulder-clay. If this is the case, then I can only say that it is the best-kept secret in geological literature. Where are the signs in the Q.J.G.S. or the Geological Magazine of this change of opinion? Who are the recusants? I do not think they are to be found in our University chairs or in the Geological Survey, and certainly not in those of Ireland.

Though the context shows clearly enough that Professor Gregory intends a general assertion of the marine origin of all boulder-clay, I do not think he sufficiently realizes that if he and the "hidden

hand" are in the right, not only a part but the whole of the glacial geology built up by patient labour of investigators from 1872 onward is wrong, and floating ice must resume its place—our moraines, our glacier lakes, our unglaciated areas, all, all must go. And how does Professor Gregory proceed to make good his case? First, as to the Central Plain, by an appeal to the evidence produced three-quarters of a century ago by Oldham, supplemented a quarter of a century later by Kinahan, of the occurrence of shell fragments at several localities, and one single shell identifiable by name, (*Buccinum undatum*) from an esker at Moate. The whole evidence has been sifted again and again by Irish geologists, only to be rejected. In the Dublin memoir Mr. Lamplugh states explicitly the several grounds upon which the Geological Survey rejected the marine hypothesis, and Professor Gregory should surely make some attempt to answer these arguments before he undertakes to reinstate it in geological literature. Professor Gregory contributes one solitary discovery of his own of a reputed marine organism in an esker, to wit, lobate calcareous incrustations upon boulders, one of which he submitted to Madame Lemoine, of Paris, who identified it as a *Lithothamnium*, a genus of calcareous algæ, enormously abundant in the Polar seas. It would be interesting to learn how many specimens were sent, and whether any were incrustations of the inorganic type that are very common in limestone gravels; and also whether Madame Lemoine was familiar with the tufa-invested pebbles that are found in streams in limestone countries.

Professor Gregory also found minute calcareous tubular incrustations—by the description, much resembling those due to deposition round roots—upon pebbles, and though Sir Sidney Harmer declined to admit their Bryozoan nature Mr. Alex Gray formed a different opinion. Dr. Gregory, however, considers that in view of Sir Sidney's adverse verdict judgment should be suspended. To account for the extreme rarity of fossils in eskers, Dr. Gregory adopts Kinahan's suggestion that in coarse gravels shells would not easily escape removal by solution. On this point an observation by Professor Sollas is valuable. He says that he and Mr. Praeger "were persuaded that it only required careful search to discover traces of marine organisms [in the Maryboro esker]; we searched intently from early morning to late evening, but without success; not a trace of a shell rewarded our efforts, and this notwithstanding the favourable character of much of the material composing the esker, which from its fineness and somewhat argillaceous nature was well fitted for the preservation of fossils had these at any time been present". Luck was clearly against them, for Kinahan found "a few small fragments of broken shell".

But how does Professor Gregory escape the dilemma which the admitted rarity of marine organisms in the eskers presents? He relies upon the supposed poverty of life in an ice-covered sea and supports the proposition by a judicious selection of extracts from records of

Polar exploration, almost every one of which can be answered from the same source thus—" as was pointed out by Brown (Quart. Journ. Geol. Soc., vol. xxvi, pp. 638, 688), many parts of the Greenland fiords, owing to the disturbed and muddy condition of the water, ' are bare of marine life,' and ' unfavourable for sea-animals ' "; but Brown is also emphatic in declaring the richness in fossils of some of the fiord muds, and he follows the words just quoted by this remark: " Accordingly, if the bed of the Arctic Ocean in these places were raised and we found the mouth of a valley with laminated beds of clay rich in Arctic shells . . ." Professor Gregory's own experience in Spitsbergen refutes the suggestion he now puts forward, no less than does the testimony of Cole, Lamplugh, and others to the abundance of shells in the mud-bank at the snout of the Sefström glacier.

The citation of Nansen for the poverty of plant-life in the Arctic Sea where ice-covered and the rarity of Foraminifera in the plankton loses its significance when confronted with the following excerpts from vol. v of the report of his expedition: " *Globigerina bulloides* exists in great quantities and varying size in the great depths of the Polar seas." In "all the plankton samples taken later during the expedition there is quite an abundant animal life". Professor Gregory's comment that " The poverty of plant-life involves the rarity of animal life " is contradicted by Gran, who says, in the same volume, " It is difficult to understand how all the crustaceans (*Calanus finmarchicus*, etc.) that swarm in the upper strata can find the means of sustaining life." Mr. James Murray, of the first Shackleton Antarctic expedition, is quoted as saying: " On the shore there is no vestige of marine life, animal or vegetable, such as is found in the littoral zone of other coasts." Place against this the description by Professor David and Mr. Raymond Priestley of raised beaches, e.g. " But perhaps the most interesting feature of this deposit was the presence of hundreds of small shells", and again," In the gravels and muds [in the Dry Valley of the Ferrar Glacier] up to a height of 50 feet fragments and whole shells of *Pecten colbeckii* and the same *Anatina* previously mentioned were very common, hundreds of fairly perfect shells being collected . . . the beach on which they occurred was two or three miles long."

In another place Professor Gregory alludes to the work of Mr. Joseph Wright, of Belfast, as showing the boulder-clay " to contain widespread indigenous foraminifera ". The word " indigenous ", of course, begs the whole question, the fact being that along a narrow belt of the east coast of Ireland the boulder-clay contains Foraminifera, among which *Nonionina depressula* greatly predominates, but *there are also species of exclusively Liassic or Cretaceous range*. Which are the true indigenes ?

One may also fairly ask another question. Why has no one, neither Professor Gregory in his flying traverses nor the investigators resident in Ireland, ever found a shell or even some of Kinahan's

"small fragments of broken shell" *in the boulder-clay* of the Central Plain, of which some thousands of square miles was, according to Professor Gregory, occupied by the Esker Sea, with a maximum depth of over 60 fathoms?

Just as he fails to realize the full consequences of his dictum regarding the marine origin of boulder-clay, so equally he overlooks all that is implied by his 400 feet submergence. Perhaps he will permit me to supply the omission by the convenient method of comparison with an area where the conditions his hypothesis requires were most exactly paralleled. I allude to the Baltic area—here, according chiefly to Brögger for Norway, de Geer for Sweden, and Sederholm for Finland, the shrinkage of the great ice-sheet of North-West Europe coincided with a depressed condition of Fenno-Scandia, so that the ice deposited its great moraines the Ra, or the Salpausselka, with which our author specifically compares the Irish eskers, under the waters of a greatly enlarged Baltic, in which finely laminated muds, the "varviglera" of de Geer, were laid down. Apart from the interest of de Geer's ingenious use of these seasonal clays for the purpose of a time scale, the deposits are invaluable for the information they yield, both in Norway and Sweden, regarding the biological or ecological conditions of a sea extraordinarily like that postulated by Professor Gregory. The muds, sands, and gravels are by no means sterile, but over large areas yield a rich, abundant, and well-preserved fauna of truly Arctic types. The level indicated by the deposits at the best-marked stage is almost exactly that assumed by Professor Gregory, namely 135 metres. Is it too much to ask for even a single shelly deposit in the Irish plain comparable with those Brögger has described?

I have had some opportunity of examining sections in many parts of Ireland during the past ten years, yet I have nowhere, except near Belfast, found anything in any degree comparable with these truly marine deposits; on the contrary, the boulder-clays, such as that covering the glaciated pre-Glacial beach in Ringabella Bay, co. Cork, are, as a rule, wholly devoid of the least semblance of lamination or bedding, and the materials, mud, sand, and stones, are confusedly intermingled in a fashion quite incompatible with deposition in water.

To conclude, the memoir seems to me so deficient in observational basis, and the far-reaching implications so generally ignored, that, attractive as the main proposition may seem, it should be regarded merely as an ingenious guess, in support of which evidence might well be sought by some geologist having time and inclination to make a methodical and persistent attack upon the problem.

Note on a Collection of Echinoids from the Limestone-lenticles in the Sand-pits of Shenley Hill.

By Herbert L. Hawkins, D.Sc., F.G.S., Professor of Geology, University College, Reading.

At the request of Mr. H. Woods, F.R.S., I have examined a small series of Echinoids belonging to the Sedgwick Museum, Cambridge, collected by the late J. F. Walker from the sand-pits on Shenley Hill, near Leighton Buzzard. Mr. G. W. Lamplugh has sent me four additional specimens from the same locality. The matrix seems to be the same in all the examples except D, and agrees absolutely with a sample of the Limestone-lenticles sent for comparison by Dr. F. L. Kitchin. The age of this Limestone is a subject of controversy (see Geol. Mag., January–March, 1920), and a critical analysis of its fauna seems the only means of deciding the issue. Unfortunately, most of the Echinoids are very indifferently preserved so that specific determination is often doubtful, and in some cases impossible.

Twenty-four specimens were submitted to me by Mr. Woods, and I have placed numbers on the boxes in which they were sent. Under those numbers they are referred to here. The following is the list according to my determinations :—

1. Internal mould of ? *Peltastes* or ? *Salenia*.
2. Internal mould of ? *Pseudodiadema* or ? *Diplopodia*.
3. "*Pyrina*" sp. nov. (? nov. gen.).
4. *Pyrina* sp.
5. Internal mould of *Pyrina* sp.
6. *P.* cf. *inflata* d'Orbigny.
7. *P.* cf. *desmoulinsi* d'Archiac.
8. *P.* cf. *desmoulinsi* d'Archiac.
9. *P.* aff. *lævis* Agassiz.
10. *P.* sp. (or spp.). Two specimens.
11. *P.* aff. *lævis* Agassiz. Two specimens.
12. *P.* aff. *lævis* Agassiz.
13. *Catopygus columbarius* Agassiz. Two specimens.
14. *Nucleolites lacunosus* Goldfuss.
15. "*Echinospatagus*" aff. *murchisonianus* (Mant.).
16. Internal mould of ? *Cardiaster* or *Holaster*.
17. Internal mould of ? *Cardiaster* or *Holaster*.
18. Indeterminable Echinoid fragment.
19. *Cardiaster* ? *latissimus* Agassiz.
20. *C.* cf. *fossarius* (Benett).
21. *C.* cf. *fossarius* (Benett).

Mr. Lamplugh's specimens are —

A. Internal mould of *Pseudodiadema* (? No. 2 above).
B. Obscure specimen (? same form as A).
C. ? *Cardiaster* sp. Two very small specimens.
D. Mould and counterpart of *C.* aff. *latissimus* Agassiz (see note below).

A few critical notes on some of the specimens are now given, and apologies are due for their scanty character; but pressure of academic work denies opportunity for prolonged research at the

present time, while delay in publication of the report would in some measure defeat the object in view.

3. "*Pyrina*" sp. nov. This is a remarkable and fairly well-preserved specimen, which I am unable to refer to any form hitherto described; it is improbable that it can belong to *Pyrina*, however that genus be interpreted. At first sight it gave the impression that another specimen of the rare *Holectypus bistriatus* Wright had turned up; even now it is impossible to examine it without recalling *H. hemisphæricus* from the Inferior Oolite. However, the characters of the apical system, tuberculation and adoral surface show clearly that it possesses more attributes of the ill-defined series usually called *Pyrina* than of the Holectypidæ. The inflation of area 5 between the periproct and peristome is the only *superficial* feature distinguishing the form from an *Holectypus* with marginal periproct, for the peristome is not displayed. While convinced that the species is undescribed, I prefer to await opportunity for figuring and fully analysing it before giving it a name. This I hope to do in the course of a few months.

4. *Pyrina* sp. This ill-preserved specimen agrees in proportions with the Senonian species *P. atacica* Cotteau, but shape is an almost valueless feature in specific determination of the Echinonëidæ. No. 5 is probably the same form.

6. *Pyrina* cf. *inflata* d'Orbigny. A thick, subglobular *Pyrina* that may be a truncated variety of this Cenomanian species.

7 and 8. These are both rather broader than typical specimens of *P. desmoulinsi*, but otherwise seem to agree with that species.

9. *Pyrina* aff. *lævis* Agassiz. Undoubtedly the form so named by Wright. Both specimens under No. 11 are similar in proportions, while No. 12 (the best-preserved specimen in the collection) is again Wright's *P. lævis*.

4–12. It may be remarked that all the specimens of *Pyrina* are probably shape-variants of a single species; the forms attributed to *P. lævis* being immature. Their range of variation is not so great as that shown in the modern analogue, *Echinonëus cyclostomus* Leske (see Westergren, 1911).

13. *Catopygus columbarius* Agassiz. There can be no doubt that the larger of the two specimens is a short form of this common species. The smaller one might be ascribed to *Caratomus*, but its bad preservation mades definite determination impossible. In either case no stratigraphical difference would be involved.

14. *Nucleolites lacunosus* Goldfuss. This is one of the few confident identifications in the series.

15. "*Echinospatagus*" *murchisonianus* (Mantell). A small, quite uncrushed specimen in which all surface ornament has been destroyed in extracting the test. The species to which it is referred is the only one to which it bears any resemblance, and the similarity is very close. I do not know the correct generic name for the form, so use that employed by Wright; there is no doubt as to the affinity

between the Shenley specimen and that figured in Wright's Monograph, pl. lxiv, fig. 1, but the former is slightly smaller.

16 and 17. These small internal moulds might be referred to *Cardiaster* or *Holaster* with equal reason. If they are Cardiasters, the nearest approach would be *C. benstedi* Forbes, from the Lower *Greensand*; if *Holasters*, *H. lævis* (de Luc) from the Cenomanian.

19—21. If shape is of any use in recognition of species of *Cardiaster*, the suggestions made seem the most reasonable; they are given without any real confidence.

The only specimens whose determination is sufficiently precise to afford safe stratigraphical evidence are Nos. 6—9 and 12—15. *Pyrina inflata* was described by d'Orbigny as occurring in the Cenomanian of Le Mans (Sarthe), where the general Echinoid fauna shows strong affinities to that of the "Top-beds" of the Upper Greensand. *Pyrina desmoulinsi* is characteristic of the "Chloritic Marl" and associated deposits. *P. lævis* is a "Warminster" species, probably from the highest beds or "Cornstones". *Catopygus columbarius* (and *Caratomus rostratus*) occur at the same horizon, and in the lowest part of the Chalk itself (sub-zone of *C. columbarius*). *Nucleolites lacunosus* occurs in the zone of *P. asper*, and ranges up into that of *Am. varians*. "*Echinospatagus*" *murchisonianus* is recorded by Jukes-Browne, in the Survey Memoir, from the zone of *Am. rostratus* (Malmstone) of Blackdown and Haldon. This summer I found it in abundant fragments at the last-named locality, always in the uppermost, chalcedonic beds. These have also yielded a mould of *Anorthopygus orbicularis*, a fossil familiar at Le Mans, so that they may well contain coastal deposits of "Chloritic Marl" age. *Cardiaster latissimus* is similarly recorded from the Malmstone, and in Western England has been found at Golden Cap (Dorset) *fide* Wright, in sands presumably equivalent, in part, to the Blackdown and Haldon beds.

All definite indications seem to point to an horizon roughly corresponding to the "Warminster top-beds" (of the Survey Memoir) for the Shenley Echinoids. It has been shown that a large proportion of the fossils recorded from Warminster were in reality collected from the "Cornstones" of adjoining districts, and so belong rather to the base of the Chalk than to the top of the Greensand. The outstanding feature is the relative abundance of *Pyrina*, about half of the specimens being referable to that group. This probably indicates local littoral conditions, since *Echinoneus*, the modern representative of the family, inhabits tidal flats. The absence of *Discoidea subuculus* from the collection is thereby made noteworthy, since that species is usually far commoner than any others in the zone of *P. asper*.

The only specimen in the collection referred to a species belonging to an earlier zone than that of *P. asper*, is "*E.*" *murchisonianus*. There can be no question as to the indigenous quality of the specimen; it is quite unbroken, and of too delicate a texture to have survived

much attrition; but, on the other hand, its specific identity is far from proved. With this possible exception there is nothing in the Echinoids to suggest that the limestone from which they came is older than the *P. asper* zone; while positive evidence (*C. columbarius* and *N. lacunosus*) and negative evidence (*D. subuculus*) agree in suggesting an horizon even higher than the uppermost Selbornian.

Note inserted in proof.—Mr. Woods has sent me six radioles of *Cidaris* from Shenley. Three of these certainly belong to *C. bowerbanki*, a "Grey chalk" species. The other three probably represent the same species. Dr. Kitchin has sent a specimen of ? *Cardiaster* or *Holaster* (Mus. Pract. Geol., Nos. WM 4741 and 4742) from the nodules in the *mammillatus*-zone near Leighton Buzzard. This specimen agrees exactly with No. D above, both in form and matrix. It is not specifically determinable.

The Interglacial Problem and the Glacial and Post-glacial Sequence in Northumberland and Durham.

By David Woolacott, D.Sc., F.G.S.

(*Concluded from p. 32.*)

THE features of the Glacial deposits and associated phenomena just discussed are in general so clear that most observers would arrive at the same conclusion regarding them, but there are some other features about which, either due to their controversial nature or the conflicting character of the evidence, there is not yet such general agreement. These are (*a*) the evidence for Interglacial Periods in the Drift of these counties, (*b*) the raised beaches of East Durham, (*c*) the origin of the leafy clays, (*d*) the explanation of the distribution of fragments of certain rocks —Flint, Chalk, Magnesian Limestone—in the Superficial Deposits.

1. The evidence for Interglacial Periods. In my paper on the Superficial Deposits of the Northumberland and Durham Coalfield, I state that "as far as the available evidence goes there does not seem to be anything pointing to an Interglacial Period or Periods",[1] and Dr. Smythe in his study of the Glacial Geology of Northumberland has evidently arrived at the same conclusion as regards the whole of that county, as he states that "No classification of the boulder-clays of Northumberland seems possible, though locally there is frequently evidence of two clays of different origin".[2] In his description of the glacial deposits of South-East Durham

[1] Quart. Journ. Geol. Soc., vol. lxi, 1905, p. 68. I also state that "some of the thicker deposits (of sand and sandy clay found intercalated in the boulder-clay) may represent epochs when the ice was melting quicker than others, but whether they can be considered in any sense as 'Interglacial' is very doubtful".

[2] *Glacial Geology of Northumberland*, op. jam cit., p. 93.

Trechmann has brought forward evidence in favour of an Interglacial Period between the deposition of the Scandinavian and the British (or Main) Drift, and has suggested a possible Interglacial episode between the formation of the boulder-clay with only western erratics in it, and the more northerly derived deposit with Scottish, Cheviot, and other rocks.[1]

I have already discussed my views regarding the Interglacial controversy, and propose to examine the subject from the standpoint stated. The evidence for an Interval-in-the-Glaciation which may possibly be Interglacial in character between the Scandinavian and British Drift is much stronger than that for even a Glaciation-interval between the two British Drifts. The general sequence of the boulder clays in Northumberland and Durham stated by Dr. Trechmann is correct. Along the coastal region of Northumberland and Durham this sequence is (*a*) Scandinavian Drift, (*b*) Drift with western erratics,[2] (*c*) Drift with Scottish, Cheviot, and Western boulders. The Scandinavian Durham basement clay is overlaid by the Tweed-Cheviot-Lake District boulder-clay with Interval-deposits between at Warren House Gill; the evidence proves that the western-derived clay was deposited along the coastal region of South Northumberland, and was then removed by the southerly moving Tweed–Cheviot ice, hence the mixture of Lake District, Cheviot, and Scottish erratics along the Durham coast. Clay with only Lake District–Tees Valley boulders has been proved to occur in a depression at Hartlepool,[3] and the western-derived clay can be seen under that from the north along the Northumberland coast between Bamburgh and the Wansbeck.[4]

The main difficulty in accepting that there was an Interglacial period between the deposition of the Scandinavian and the British Drift near Castle Eden is that the hypothesis seems to demand that there was no British ice on the east of Durham during any stage of this, the maximum, extension of the Scandinavian ice-flow. It seems hardly possible that this ice could occupy the greater part of the North Sea area, without there being a concurrent gathering of ice on the uplands of Scotland and England and therefore a flow at the same time across the North of England.[5] It has always been

[1] Op. jam cit., 1920, p. 193.

[2] There is, however, distinct evidence that ice bringing Scotch erratics reached the Northumberland coastal region before that from the Lake District.

[3] Trechmann, Quart. Journ. Geol. Soc., vol. lxxv, pt. iii, 1920, p. 192.

[4] Smythe, *Glacial Geology of Northumberland*, p. 94.

[5] The difficulty introduced by this is seen when the Basement clay of Holderness and the Scandinavian Drift of Durham are compared. The former contains English and Scottish erratics mixed with foreign rocks ("Geology of Holderness": Mem. Geol. Surv., pp. 18–19), the latter only such boulders as could be brought by the passage of an ice-sheet from Norway. The Durham Basement clay must therefore on this hypothesis belong to an earlier period of glaciation than that of Yorkshire with an Interglacial period (or possibly two such intervals between). This is, however, not impossible, but it is evident

generally agreed by European glaciologists, who accept a series of Interglacial periods, that the time of maximum extension of the Scandinavian ice or Second Glacial Epoch (Saxonian, J. Geikie) was contemporaneous with extensive glaciation in England.[1] This difficulty does not occur if the loess deposit is an "Interval-deposit" marking an "Interval-in-the-Glaciation", and I submit that while appreciating the strength of Dr. Trechmann's argument and admitting that his work has added considerable interest to the study of the glaciology of the north-east of England, until the evidence is more conclusive in the face of this difficulty it is better to regard it as such than as an Interglacial formation.

The evidence for an "Interval-in-the-Glaciation" between the Scandinavian and the British Drift is founded on (1) an Interval-deposit of loess, with its decalcification and the weathering of contained rocks, (2) the possible formation of a shore-line from which the shell-bearing materials of the Kaims were derived, and (3) the possible erosion of valleys in the interval. I propose to discuss this evidence briefly:—

(1) While admitting that the deposit at Warren House Gill is true loess and that it is an Interval-deposit of considerable interest, it may be doubted whether an Interglacial period is necessary to account either for its occurrence or the formation of concretions in it or the weathering of the contained boulders. Dr. Trechmann states that loess was formed on the edge of the advancing Scandinavian ice-sheet and was overridden and incorporated with the Drift.[2] May not therefore the deposit at Warren House Gill have been formed on the margin of the ice-sheet, before the oncoming of the British ice on to the area? If so, it does not seem to demand a prolonged Glaciation-interval to account for its occurrence. I have noticed in the local drifts (and some years ago carefully examined) small pockets and spreads of finely divided material, which I have always regarded as the silt of glacial streams, and it seems possible to me that this deposit of loess was formed on the edge of the ice-sheet from the rock-flour carried off by waters from the margin of the ice.[3] From my observations of the quickness with which certain processes may take place, the decalcification of the loess and the formation of concretions in it, while strengthening the argument for an Interval of some duration, do not necessarily imply an Interglacial period. Decomposed boulders in the loess are also evidence in favour of an Interval, but again are not conclusive proofs of an Interglacial period. I have obtained from the

that the glacial deposits of North-East England will have to be critically re-examined if an Interglacial epoch between the Durham Scandinavian and the British Drifts is accepted as proved.

[1] J. Geikie, *Great Ice Age*.

[2] Op. jam cit., Quart. Journ. Geol. Soc., 1920, p. 176.

[3] J. Geikie, Address to the Geol. Section of the Brit. Assoc., Newcastle, 1889, p. 19, where a similar view of the origin of the loess is given.

Scandinavian Drift a quite friable granite, and decomposed and weathered granites occur in other boulder-clays.

(2) Because of the less Arctic character of the fauna of the shell-bearing Kaims when compared with the Scandinavian Drift, Dr. Trechmann has suggested that the former were deposited on the edge of the Tweed–Cheviot glacier at a later period of glaciation than the maximum extension of the Scandinavian ice, an Interglacial shore-line having been formed during the epoch.[1] Arguments from derived faunas can never be very conclusive, as the shells in the Scandinavian Drift may not only have been brought from a greater depth than those in the Kaims, but they may also be from deposits formed at a different period. It is, however, probably from a consideration of the faunas in the different Pleistocene deposits in the north-east of England that the surest evidence is to be obtained as to whether the Glaciation-interval between the deposition of the foreign and British drifts is an Interglacial one. As the shell-bearing Kelsey Hill deposits[2] appear to have been pushed inland at the same time as the Durham Kaims were formed, i.e. the period when the Tweed–Cheviot and other ice was being forced along the coast, a comparison of the faunas in these two deposits would be of interest in connexion with this subject; and as there is a possibility that the Sewerby Raised Beach is an Interval-deposit, a comparison of its fauna with that of the Durham Kaims would be worth considering; indeed, it would be of value if complete comparative lists of the faunas of all the Pleistocene deposits in Durham and Yorkshire were published and critically examined, including the deposits mentioned and the Scandinavian Drift of Holderness (which may be of later formation than that of Durham), the Bridlington Crag, and the raised beaches of the Durham coast. If it can be proved that a shore-line with a temperate fauna was formed between the deposition of the Scandinavian Drift near Castle Eden and the British boulder-clays it would considerably support the argument for an Interglacial period having occurred between these formations.

In connexion with the material composing the Kaims there is one piece of evidence that might have been advanced in favour of the view that they belong to a later period of glaciation than the Scandinavian Drift, and that is that if a shore-line was formed it would have probably contained boulders of Scandinavian rocks derived from the basement Drift, and therefore the Kaims should contain such rocks. I have never seen any undoubted Scandinavian pebbles in the Kaims near Sunderland nor in the Sheraton mounds, but Trechmann records "a fragment apparently of a rhomb porphyry" from the latter.[3] It would be of interest to know

[1] Op. jam cit., p. 189.
[2] *Geology of Holderness* (Mem. Geol. Surv.), 1885, p. 53.
[3] Quart. Journ. Geol. Soc., vol. lxxi, pt. i, 1915, p. 74.

whether foreign rocks do occur in the Kaims in any quantity,[1] as if so it would undoubtedly lend support to the argument in favour of the formation of a shore-line, as the loose materials of such a deposit would be much more easily removed than the stiff Scandinavian Drift.

(3) It has also been suggested that the valleys of "Hesleden", "Castle Eden", and "Hawthorn", which are now filled with boulder-clay containing Scottish, Cheviot, and Lake District erratics, and which I have described as Preglacial, were eroded between the deposition of the Scandinavian and the overlying British Drift. I considered these valleys when I first described them to be mature Preglacial waterways, and I am not aware of any evidence which proves they were formed during an Interval-in-the-Glaciation or were modified in such a period. We cannot be certain that some of them do not contain Scandinavian Drift at their base,[2] and if it was a lobe of this ice that reached the Durham coast they may be Preglacial and yet not have foreign boulder-clay in them. These valleys should, however, be examined as opportunity permits for the occurrence in them of Scandinavian Drift, and for their possible formation during a Glaciation-interval.

It has been further suggested that there was an Interglacial episode during the deposition of the Main or British drifts. Trechmann has noticed the occurrence of clay filling a depression at Hartlepool, which contains only boulders brought from the west down the Tees valley; it is also possible that such western-derived drift may occur at the base of the Preglacial "Tyne" or "Sleekburn"; and Smythe has shown that in Northumberland, between Bamburgh and the Wansbeck, there are two boulder-clays, one mainly derived from the west and an upper with material from the north (Tweed valley, etc.). There are no Interval-deposits or other evidence in support of this suggestion, but it is quite possible that there is an "Interval-in-the-Glaciation" between the formation of these two drifts, as the supposed later glaciation which brought the material from the north was undoubtedly the greater, and so may

[1] Flint and Chalk are, as I shall show, so peculiarly distributed in the Superficial Deposits that I do not regard them as all having been brought by the Scandinavian ice to the area.

[2] About 1903 Mr. Bell, of Bishop Auckland, sent to me two or three small pieces of rock which he had obtained from material dug up in excavations in Castle Eden Dene. One was a fragment of Laurvik syenite. I visited the locality shortly afterwards, and decided that it had been obtained from a gravel deposit and not from boulder-clay. I did not, therefore, record it at the time. In 1910 I saw a boulder of Laurvik syenite cemented in the foot of the cliff north of Castle Eden near Warren House Gill, and at the same time saw other evidence—that Dr. Trechmann has since, along with much new material, fully described—which convinced me that the Scandinavian ice had reached the Durham coast and that the boulders were true erratics. I therefore recorded the boulders in the Boulders Com. Report of the Univ. Durham Phil. Soc. (Proc. Univ. Durham Phil. Soc., vol iv, pt. ii, 1910–11, pp. 89–90) and in Proc. Geol. Assoc., 1912.

have removed all such evidence as well as the greater portion of the drift of the earlier period. The superposition of these two drifts is, however, quite explainable on the hypothesis of a continuous glaciation, without a Glaciation-interval or Interglacial period, as the ice-streams coming from the west may have reached the coastal region before they were diverted southwards by the pressure of the Scandinavian ice in one continuous glaciation; thus boulder-clay with western erratics would later be overlaid by drift containing northerly derived material. Further evidence would seem to be necessary before an "Interval-in-the-Glaciation" can be taken to be proved in the deposition of the purely British drifts of Northumberland and Durham.

In connexion with the Interglacial Problem there are three deposits of special interest apart from those already discussed. These are (1) the Sewerby Raised Beach near Bridlington, (2) the deposit at Horsebridge Head, north of the mouth of the Wansbeck, and (3) that at the Lyne Burn.

(1) Trechmann has stated that the evidence for the Preglacial age of the raised beach at Sewerby, near Bridlington, is not conclusive,[1] and if it is eventually proved that there are Glaciation-intervals in the formation of the Drifts of the North of England it would seem possible that it could have been formed in such a period.

(2) The gravel deposit at Horsebridge Head, which rests on the rock surface beneath boulder-clay,[2] has been thought by some observers to be a Preglacial raised beach[3]; but Dr. Smythe after a very careful examination regards it as the deposit of an early Glacial stream.[4] The evidence obtained from an examination of the boulders is not conclusive. Chalk, flints, fossiliferous magnesian limestone, Cheviot porphyrite, igneous and metamorphic rocks all occur in it.[5] Bullerwell also records a fragment of a shell (*Ostrea* ?) from it. There seems to be material from several sources, including Scotland, the Cheviots, the Magnesian Limestone (whose present outcrop is several miles further south), and from Cretaceous strata. It is rather a puzzling formation, but it certainly seems to afford evidence of a passage of ice from the north before the deposition of the more westerly derived boulder-clay overlying it, and it is possible that it is an Interval-deposit or even a true Interglacial bed.

(3) A deposit containing very much the same admixture of material, including greywacke and garnetiferous mica-schist (Pitlochrie ?), occurs a few miles to the north at the mouth of the Lyne Burn; it, however, rests on reddish prismatic clay below which is typical boulder-clay, and is covered by blown sand. This deposit again might

[1] Op. jam cit., p. 190.

[2] There is a photograph of this deposit in my paper on the Superficial Deposits, op. jam cit., p. 68.

[3] e.g. Bullerwell, "Section of the Cliffs near Newbiggen by the Sea, etc.": Nat. Hist. Trans. Northumberland, etc., vol. iv, pt. i, 1914, pp. 61–6.

[4] *Glacial Geology of Northumberland*, ibid., pp. 98–9.

[5] Bullerwell regards some of the granites as being from Aberdeen.

be regarded as a raised beach, but Smythe considers it to be similar in origin to that at Horsebridge Head; pointing to a passage of ice from the north after the deposition of the western derived Drift. Is it possible that the Lyne Burn deposit is also an Interval- or Interglacial deposit? The critical examination of such beds makes the Drift of the north-east of England much more complicated than it at first appears to be.

2. In the papers on the Superficial Deposits and the Origin and Influence of the chief physical features of Northumberland and Durham, certain regularly-bedded shell-bearing gravels and sands occurring up to the 150-feet contour were described as raised beaches. Various arguments have been advanced by different geologists against considering these deposits as uplifted marginal sea-deposits, such as, they cannot be traced north of Tynemouth nor along the Yorkshire coast nor far inland, also that shell-bearing sands and gravels that have been carried inland by ice occur in Durham at a higher level; but all such arguments disappear before positive evidence obtained from an examination of the deposits. In the June number of the GEOLOGICAL MAGAZINE for 1920 there is described an exposure of these beds at Easington, from an examination of which it should be possible to definitely decide whether these deposits are raised beaches.[1] After the exact method of the formation of these sands and gravels has been agreed upon, their extent and peculiarities may be more fully discussed.

The submerged forests of the Durham coast rest on boulder-clay; that at Whitburn Bay is certainly formed from a growth of vegetation in situ. They appear to mark a slight recent depression, but there is the distinct possibility that their present relation to the sea-level is due among other causes to the slipping and settling down of the superficial deposits in the valleys and depressions in which these formations rest, and therefore that they do not mark any regional sinking of the crest.

The complex character of part of the Superficial Deposits in the north-east of England can be studied in the Tyne valley. These have been carefully examined by E. Merrick, who has worked out the sequence of the beds.[2] The Preglacial "Tyne" reaches a maximum depth beneath sea-level of 169 feet at Dunston, west of Gateshead, about 10 miles inland, while at its mouth it is only 141 feet. The slope of bed rock is of a switchback nature due to the formation of a series of rock basins along its course by glacial action. This old depression is partly filled by a series of deposits of very varying character, the exact origin of which is very difficult in some cases to determine. They probably include true glacial deposits of boulder-clay, fluvio-glacial beds, glacier-lake deposits, estuarine deposits (formed when the coastal region was embayed at the time of the

[1] I regard them as true Raised Beaches.

[2] "On the Superficial Deposits around Newcastle-upon-Tyne": Proc. Univ. Durham Phil. Soc., vol. iii, pt. iii, 1909.

formation of the raised beaches), alluvial and land deposits, and are thus partly formed of thick deposits of reassorted glacial and other material. The leafy clays were deposited in tranquil conditions, and while they are usually regarded as glacier-lake deposits some of them may also be of estuarine origin. Merrick has found in these finely laminated clays numerous tracks of some forms of locomotive invertebrate life,[1] probably of annelids, as no fossils have ever been found in them, but some of the tracks are like those of crustacea or gastropods.

The sequence worked out by Merrick includes :—

Soil.
Yellow clay (weathers into short columns, prismatic clay).
Brown clay (stiff brown clay with boulders).
Rotten loam sand.
Common clay (roughly bedded boulder-clay).
Surface leafy clay.
Black clay (with striated and unstriated boulders).
Leafy blue clay.
Scarp (boulder-clay).
Sand.

Similar leafy and other clays are found in the Tees valley.[2] Sometimes in the leafy clays boulders are found, which would appear to have been rafted by ice or vegetation and dropped into the deposit.[3]

The distribution of most of the rock-fragments in the Superficial Deposits of Northumberland and Durham can be explained from the general trend of the ice-movements in the area, but that of some rocks, such as Flint, Chalk, and Magnesian Limestone, is so peculiar as to be worthy of special notice. While many of the positions in which pieces of these rocks occur offer no special difficulty some undoubtedly do, if we accept the hypothesis that the Chalk and the Flint were brought by the Scandinavian ice from the bed of the North Sea, and, in connexion with the distribution of the Magnesian Limestone, that the direction of ice-movement down the Northumberland coast was always from north to south. Flint occurs in the Scandinavian Drift at Warren House Gill, and in a comparatively stoneless clay resting on the boulder-clay at Trow Rocks, South Shields, and at Tynemouth (Howse's Scandinavian Drift). I have never seen it in, and I do not remember it having been recorded from the typical Main or British Boulder-clay in Northumberland and Durham, but it may occur. It is present in the deposits at Horsebridge Head, and at the Lyne Burn already noticed. It has been found in the Kaims and large rolled flints occur in the gravels and sands at Cleadon (Raised Beach). The late

[1] See photographs op. jam cit., pl. i.
[2] Trechmann, op. jam cit., 1920, p. 192.
[3] See description of such a boulder by Professor Lebour, Proc. Univ. Durham Phil. Soc., vol. ii, pt. ii, 1901–2, p. 81.

Professor Lebour informed me that several had been found near the surface on the Newcastle Town Moor. Chalk has a somewhat similar distribution,[1] but boulders of it (one striated) have been found in the boulder-clays of the Tyne valley at Walker and Heaton, near Newcastle, and I have found a small chalk pebble in gravels at Ponteland, several miles north-west of Newcastle. It is almost impossible to explain this widespread occurrence of these rocks on the generally accepted hypothesis of ice-carriage to the area. The distribution of Magnesian Limestone is also worthy of note, as it has been found at several places up the coast of Northumberland (Horsebridge Head, Lyne Burn, etc.) as far north as Amble, i.e. several miles north of its present outcrop; and boulders have also been proved to occur at Walker in the Tyne valley near Newcastle, some miles west of it. Are these fragments remnants of strata that once overlaid the area beyond the present outcrop of the Cretaceous and Permian strata ?

If certain of the phenomena discussed in this paper have been correctly interpreted they appear to prove that definite changes of level have taken place in the north-east of England since the erosion of the Pre-glacial surface. The depressions in which some of the superficial deposits lie prove that prior to the Glacial period Northumberland and Durham were more elevated than at present; if an Interval- or Interglacial shore-line was formed during the early part of this epoch, then the area was only slightly above the present level when it was formed; while the Raised Beaches prove that the area was subsequently depressed and then uplifted. The latter movement was probably more pronounced along the coastal region of Durham. The depression since Pre-glacial times may have been the result of the load of ice which covered the country, and the uplift one of the results of its removal.

THE GLACIAL AND POSTGLACIAL SEQUENCE IN NORTHUMBERLAND AND DURHAM.[2]

Post-glacial.	Formation of peat beds and submerged forests.
	Extensive erosion of the Drift along main superimposed valleys. Formation of river terraces and alluvial haughs. Deposition of thick beds of assorted Glacial material.
	Formation of lakes occupying rock basins, hollows in the Drift and amongst the Kaims.
	Final erosion of Postglacial gorges of Wear, Wansbeck, Hawthorn, Castle Eden Dene, etc.
	Postglacial Tyne, Tees, and Upper Wear valleys superimposed on Preglacial valleys.
	Formation of marginal sea-deposits, followed by an uplift—maximum 150 feet—producing the Raised Beaches. Deposition of much material in Tyne valley—leafy clays, sands, etc.

[1] Has been recorded from the Horsebridge Head gravels, Lyne Burn deposit, from clays in the Tyne valley, from the Raised Beach deposit at Cleadon.

[2] This table is only intended to show the general sequence of events: there must have been considerable overlapping, but the general order in which they took place is considered to be something of this nature.

Glacial.	Disappearance of ice from counties.
	Retreat of ice from country until small glaciers occupied valleys in Cheviots and Lake District, etc.
	Final retreat of Tweed–Cheviot ice from coastal region.
	Deposition of leafy clays, etc., in the Tyne and Tees valleys in lakes held up by ice along coastal border.
	Formation of glacier-lakes in Mid-Northumberland and of associated Kaims and overflow valleys, when the Western ice had retreated and the Tweed–Cheviot still occupied the coastal border; concurrent formation of lakes in lower Teesdale and Weardale; cutting of Ferryhill Gap; commencement of erosion of gorges of Wear, Wansbeck, etc., by streams flowing from waters held up by ice.
	Formation of Grindon, Warden Law, and Sheraton Kaims on the margin of the Tweed–Cheviot ice occupying the coastal region of Durham.
	Glacier-lakes of Cleveland Hills formed during maximum pressure of the combined ice-sheets along the coastal region.
	Glacier-lakes formed in the higher regions of Teesdale, Weardale, and the Cheviots.
	Advance of Forth and Tweed–Cheviot ice and of Western ice across Northumberland and down Teesdale; all these streams were diverted southwards by the pressure of the Scandinavian ice-sheet.[1]
	Possible Interval in Glaciation.
	Advance of Western ice across coastal region.
	Possible Interval in Glaciation. Possible formation of Horsebridge Head gravels as an Interval-deposit.
	Advance of ice from Scotland along coast of Northumberland.[2]
	Glaciation-Interval. (Possible Interglacial Period, Trechmann.) Formation of Interval deposit of loess, etc. Possible formation of Interval shore-deposits and erosion of valleys.
	Advance of Scandinavian ice-sheet to Durham coast.[3]
Pre-Scandinavian Drift[4] or Preglacial.	Deposition of Teglian, Cromerian, and other deposits on the North Sea area.
	Formation of Preglacial valleys of "Wash", "Tyne", "Tees", etc.

[1] and [3] If Interglacial Periods did not occur, then the Scandinavian ice must have occupied the North Sea area continuously during the glaciation of the two north-eastern counties. It was the first to reach the Durham coast, and the Tweed–Cheviot ice was held along this region by it until the retreat of the British ice had commenced. The Sewerby Raised Beach, the Horsebridge Head deposit, as well as the Interval-deposits given, may have been formed between 2 and 4. The Basement Clay of Holderness, if, as already suggested, it is not contemporaneous with the Durham Scandinavian Drift, may have been deposited and the Bridlington Crag also pushed inland in the period between 2 and 4. The Kelsey Hill deposits were probably carried inland at the same time as the Durham Kaims of Grindon, Warden Law, and Sheraton were formed.

[2] As already stated there is evidence for an advance of ice from Scotland along the coastal region of Northumberland before the western ice occupied the area.

[4] On the hypothesis that there was an Interglacial period before the Scandinavian ice reached England; if only a Glaciation-Interval, then Preglacial as far as North-East England is concerned.

On *Eugyrinus wildi* (A. S. W.), a Branchiosaur from the Lancashire Coal-measures.

By D. M. S. Watson, University College, London.

THE unique type-specimen of *Hylonomus wildi*, a small amphibian from the marine roof of the Mountain Four-feet Mine of the Lower Coal-measures at Trawden, near Colne, Lancashire, is now in the Manchester Museum, No. W 1222.

This specimen was accurately described by Dr. A. Smith Woodward (Geol. Mag., 1891, pp. 211–13). Some time ago I decided to endeavour to develop the dorsal surface of the skull, and was successful in the attempt. The skull is quite uncrushed, although the quadratojugal of the left side had been separated before burial. It is now represented by an exquisitely sharp impression of the outer surface of the posterior half, squeezes from which display the structure with perfection. The mould of the inner surface of the whole head, except the extreme tip of the nose, is equally well preserved. The parasphenoid and right half of the palate are in place, but somewhat concealed by the lower jaw. Finally, a fracture passing along the quadrate ramus of the pterygoid makes the structures there visible.

The skull is very small, about 17 mm. in length and breadth, and 7 mm. in maximum depth.

The general form is triangular, the quadrate region being the widest part and the nose narrow. The dorsal contour is nearly straight, descending from the occiput to the shallow nose. In transverse section the outer surface is smoothly curved, the temporal bones continuing the surface of the "table".

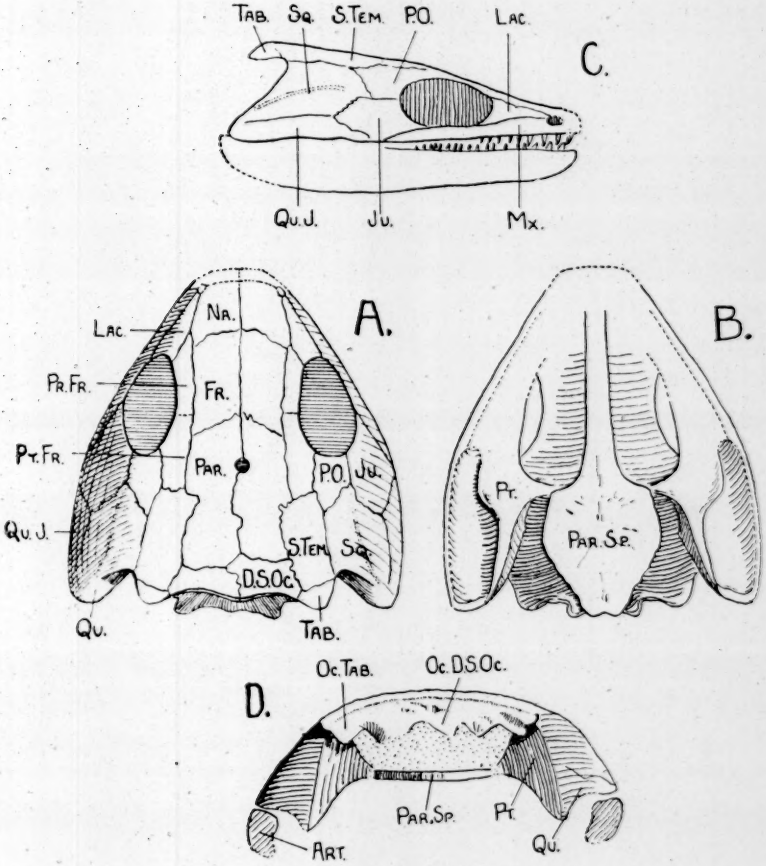
The orbits are large, lying in the anterior half of the skull and extending down to the upper edge of the shallow maxillæ. The interorbital surface is wide. The posterior edge of the right nostril is preserved and shows that these openings were small and widely separated. There is a small pineal foramen, just caudal of the hinder margin of the orbits.

The outer surface is covered by an ornament of small bosses, sometimes extended into ridges. There is a shallow groove for lateral line sense organs on the squamosal.

There are no ossifications in the neural cranium. The basis cranii is supported by a very large parasphenoid, which is posteriorly expanded into a thin hexagonal plate with a flat ventral surface. The processus cultriformis is wide, and extends very far forward.

The pterygoid is attached to the anterior corner of the enlarged plate of the parasphenoid by a narrow process, the exact details not being ascertainable. From this process the quadrate ramus passes backward as a high paraotic flange, whose upper edge touches the squamosal below the otic notch, whilst its lower margin is carried down below the general level of the palate to support the articular edge of the quadrate. The palatal ramus of the pterygoid runs

forward on the palate, and must articulate with the palatine and ectopterygoid, which bones are concealed by the lower jaw. There



Restoration of the skull of *Eugyrinus wildi* (A.S.W.) from the type (W 1222, Manchester Museum). Founded on camera lucida drawings of squeezes from the impression of the hinder part and of the mould of the anterior part. The left restored from the perfect right side. × 2·6 approx.

A. Dorsal aspect.

D.S.Oc., dermo-supraoccipital; Fr., frontal; Ju., jugal; Lac., lachrymal; Na., nasal; P.O., postorbital; Par., parietal; Pr.Fr., prefrontal; Pt.Fr., postfrontal; Qu., quadrate; Qu.J., quadratojugal; S.Tem., supratemporal; Sq., squamosal; Tab., tabular.

B. Ventral aspect.

Par.Sp., parasphenoid; Pr., pterygoid.

C. Right lateral aspect. Reference letters as before.

D. Occipital aspect.

Art., articular; Oc.D.S.Oc., occipital flange of dermo-supraoccipital; Oc.Tab., occipital flange of tabular.

is a distinct flange from the pterygoid supporting the inner surface of the lower jaw as in *Eryops*.

The interpterygoid varieties are large, but the width of the palatine and pterygoid is considerable, the pterygoid in consequence passing far forward.

On the dorsal surface the hinder margin of the skull is formed by the small tabulars, which have rounded ends, and are not produced into horns, and by the considerably larger dermo-supraoccipitals. Both these pairs of bones have large descending flanges on the occipital surface, which, as in the later Labyrinthodonta, must have covered the paroccipitals and exoccipitals. The parietals are large bones, succeeded in order by the frontals and nasals. There is a large supratemporal, which articulates with the tabular, dermo-supraoccipital, and parietal on the admesian border, with the postfrontal and postorbital in front and with the squamosal laterally. Its border enters into the margin of the large otic notch. The squamosal lies on the side of the skull, articulating above with the supratemporal. Its caudal margin is turned in under the otic notch to be attached to the upper edge of the paraotic plate of the pterygoid. Ventrally of this union the bone covers part of the hinder surface of the well-ossified quadrate. There is a small quadratojugal. The series of circumorbital bones is complete, the lachrymal extending from the orbit to the nostril as in primitive reptiles. Owing to the large size of the orbit, the lachrymal and jugal do not meet. The structure of the lower jaw is undeterminable.

The vertebral column is largely concealed by the body squamation, but such parts of the neural arches as are visible agree exactly with those of *Branchiosaurus*, and present no resemblance to any Lepospondyl elements. The ribs of the pectoral region are as described by Smith Woodward, very stout, straight, and expanded at both ends; the later dorsal and caudal ribs, though more slender, are equally straight. Of the shoulder-girdle the interclavicle is as shown in the original description, a rounded plate of bone with a distinct radiating ornament. Fragmentary remains of clavicles of a scapula and perhaps of a cleithrum are shown; they agree with the corresponding elements of *Branchiosaurus*. In the pelvis the long, slender ilium and plate-like ischium are well shown from their visceral surface, but there is no trace of a pubis.

There is a complete covering of scales on both ventral and dorsal surfaces. On the belly these have a complex arrangement, not describable in detail but recalling that of *Branchiosaurus*.

The amphibian just described is clearly a Branchiosaur. Only in the Phyllospondyli amongst Palæozoic amphibia do comparable vertebræ, ribs, and squamation occur. It is the oldest known member of its order, *Eumicrerpeton*, *Mazonerpeton*, and *Micrerpeton*, described by Moodie from the Coal-measures of the United States, coming from the considerably higher horizon of Mazon Creek. The other European forms come from Stephanian and Artinskian rocks, and from different

horizons in the Rothliegende. Thus *Hylonomous wildi* cannot be referred to its original Microsaurian genus, and as it does not fall into any described Branchiosaur genus I propose for it the name *Eugyrinus*.

The skull of *Eugyrinus* is by far the best-preserved Branchiosaur skull known, and is much more primitive in its structure than that of the well-known Permian and Stephanian genera. It differs from *Branchiosaurus* in being much longer and narrower, and in having very much smaller orbits; it is, in fact, more like the central type of Labyrinthodont skull represented by *Eryops*.

In consequence of its smaller orbits, it retains a lachrymal, and has postfrontal, postorbital, jugal, and squamosal bones much more resembling the ordinary Labyrinthodont type than those of *Branchiosaurus*. The palate of *Eugyrinus* differs from that of *Branchiosaurus* in the narrower hinder part of the parasphenoid, which in it can by no stretch of the imagination be called T-shaped; and in the much smaller interpterygoid varieties and larger pterygoids which go with them. These differences are exactly those which separate such a Rachitomous amphibian as *Dwinasaurus* from its Stereospondylous descendant, *Plagiosaurus*, and go to show that the trend of evolution in Phyllospondyli is the same as that in Labyrinthodonta. *Eugyrinus* agrees in stage with an Upper Permian Labyrinthodont, *Branchiosaurus* with one from the Upper Trias.

The skull of *Eugyrinus* is very valuable, because it shows that the general structure of the early Phyllospondylian skull is identical in essentials with that of the Labyrinthodonta. In comparison with *Branchiosaurus* it shows that the Phyllospondyli had a similar evolutionary history to that of the Labyrinthodonta, carried through at a much earlier date, and of which only the latter half is known. As the latter parts of the stories of the two groups are similar we are surely justified in expecting that the beginnings will resemble one another, and that we may take the primitive Labyrinthodonts as representing structurally the unknown ancestors of the Branchiosauria.

Thus the known Phyllospondyli can in no sense be regarded as primitive amphibia; they represent the later members of a side-line which underwent a precocious and very rapid evolution.

Eugyrinus is of geological importance, because it adds another link to the chain of evidence which proves that North America and Britain formed a single zoological province in Upper Carboniferous times. The resemblance between the vertebrate fauna of the North American Coal-measures and that of Britain is very great. Several species of fish, a number of genera of fish and amphibia, and nearly all the definitely determinable families of vertebrates occur on both sides of the Atlantic. The flora is, of course, equally similar.

The resemblances are, in fact, so great as only to be explicable

by a continuous land-bridge crossing from Britain to Canada. The marine fauna living along the southern shore of this continent should be equally uniform; and as such a bridge must have had a representative in Lower Carboniferous times it should follow that the mountain limestone faunas of Britain should be in large part identical with those of the States. It appears probable that a comparison of their faunas, founded, not on literature, but on actual material, would be a most profitable undertaking, and that it might enable British geologists to make use of the evidence of a succession of faunas which has been collected by their North American colleagues.

On the Geological Features of the Oil Region in the Northern Punjab (British India).

By H. Preiswerk, Basle.

(*Continued from p. 21.*)

B. THE OIL REGION OF JABA IN THE WESTERN SALT RANGE, MIANWALI DISTRICT (see Figs. 9 and 10).

The Oil-springs.

THE oil-springs of Jaba are situated at the foot of the steep limestone hills 1½ or 2 miles distant from the village of Jaba and 7 miles from the railway station of Massan. On the topographical map (Sheet 38, p. 9, scale 1 inch = 1 mile) the two main oil-springs are marked. The north-western spring is called Chota Kutta by the natives, the south-eastern Burra Kutta, from the brooks where they are found.

The richest oil-spring is that of Chota Kutta. It is situated immediately at the entrance of a narrow ravine which has been cut by the little brook into the steep limestone ridge. The most important of the oil-shows are on the right bank of the brook. Oil issues at several places out of the Nummulitic limestone, together with water containing sulphuretted hydrogen. The total outflow of the natural oil-springs of Chota Kutta and Burra Kutta has been collected by the Chowkeedar during three months. The daily outflow was found to be about 1 gallon (4–5 litres), three-fourths of which issues at Chota Kutta according to Lyman's estimation.

In 1912 the production of oil of the Mianwali District was 950 gallons; 1916, 1,334 gallons; and 1917, 919 gallons.

In front of the entrance to the narrow ravine, at the foot of the limestone ridge and a few yards distant from the oil-springs, some shallow shafts have been dug, from which oil and gas issue. Also a little boring has been made—30 yards below the entrance to the ravine—the depth of which is said by the natives to be 300 feet.

I have taken a sample of the oil issuing from the boring. It is

a brown and rather mobile oil with a strong aromatic smell. The analysis of this oil gives the following results :—

Specific gravity of the crude oil .	0·9242
Flash-point	75° C.

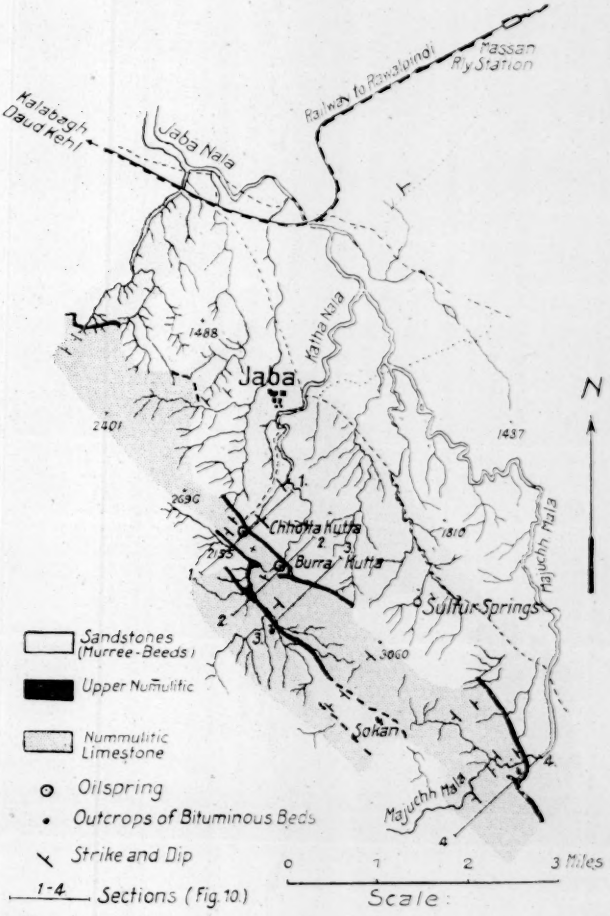


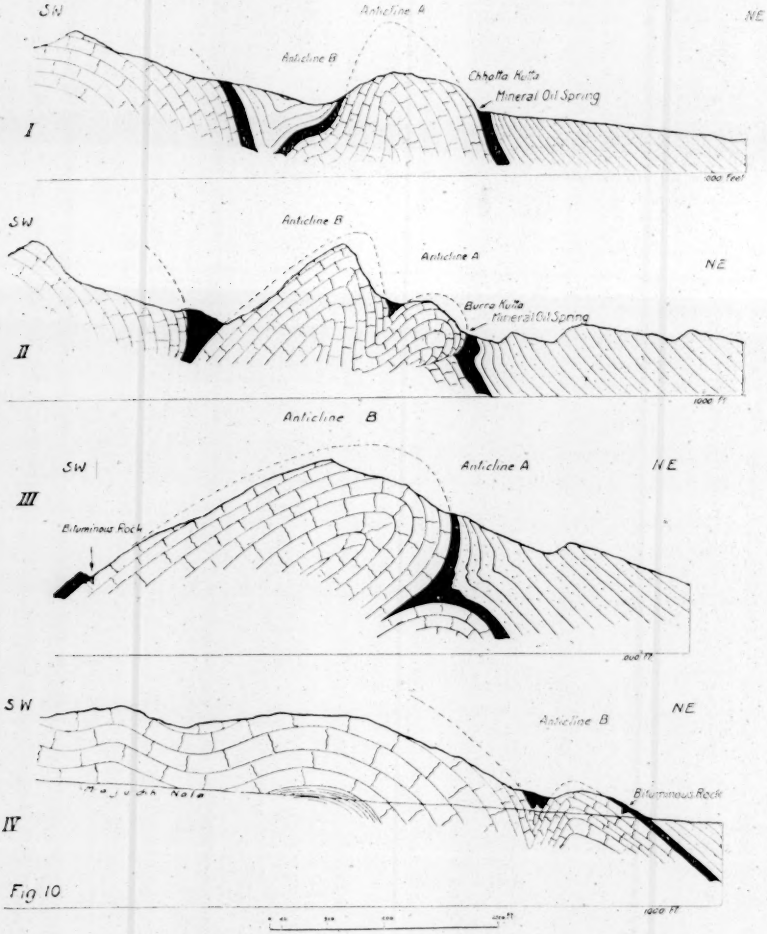
Fig. 9.

The fractional distillation gave by Engler's method :—

			Spec. grav.
I.	Fraction from 70° to 150° .	0·6 per cent	—
II.	,, ,, 150° to 250° .	7 per cent	0·8460
III.	,, ,, 250° to 300° .	24·4 per cent	0·8736
IV.	,, ,, over 300° .	60·3 per cent	0·8905
	Residue. .	7·7 per cent	—

The determination of paraffin in fraction IV gave a content of 30 per cent paraffin, while the remaining 70 per cent of fraction IV might be signified as solar oil. The whole amount of sulphur in the oil amounts to 0·43 per cent.

The oil, therefore, contains 31·4 per cent burning oil. The amount of paraffin, about 18 per cent of the crude oil, is very high. The sulphur content is moderate, and does not reach that of the limestone



oils of Ohio (0·5–0·6 per cent). The oil is to be called a heavy oil. Its composition is peculiar and hardly comparable with other oils.

The oil-spring of Burra Kutta is situated in a position quite similar from the topographical and geological point of view to that of Chota Kutta. There are about a dozen oil-shows, beginning at the

entrance of the steep ravine which has been cut through the limestone ridge by the Burra Kutta brook. The oil comes forth from the cracks of the Nummulitic limestone, mingled with sulphur water and sometimes with gas. The most westerly of the oil-shows I have seen in the Burra Kutta valley lies about 80 metres above the entrance to the gorge.

Geological Features.

Stratigraphy.—The oil-springs come forth from the uppermost beds of the Nummulitic limestone, which contains some marly layers. At the river-bank at Chota Kutta the beds lying over the limestone are covered by detrital deposits for a distance of 30–40 yards along the river. These beds, however, are very well exposed along the footpath leading through the gorge high above the brook on its north-western bank. They consist (1) of very porous limestones or dolomitic limestones (Zellenkalk, cargneule), accompanied by white gypsiferous clays. These beds are covered by (2) greenish gypsiferous clays and further by (3) pseudo-conglomeratic oolitic limestone forming a prominent ridge. This limestone consists of coarse ooliths containing in the core pieces of Nummulitic limestone. The same ridge of oolitic limestone is visible, too, down at the river bank, about 10 yards to the west of the footpath which leads from Chota Kutta to Burra Kutta.

In the sections (Fig. 10) I have marked these three characteristic rocks with the same signature of "Upper Nummulitic". Stratigraphically, as well as petrographically, there is a great concordance with the Upper Nummulitic beds in the environs of Rawalpindi. At the oil-springs of Gunda near Fatehjang, and further to the east near Kutbal, quite the same very characteristic porous limestone (cargneule) is found between the compact Nummulitic limestone and the gypsiferous marls of the Upper Nummulitic.

Above the oolitic limestones follow the Murree beds and the Siwalik group: a series of sandstones with red clays of enormous thickness.

The oldest rocks, represented in Section IV, Fig. 10, are lumpy marls lying below the Nummulitic limestone in the valley of the Majuchh Nala. These marls are rich in fossils, especially in well-preserved Echinoidea. I have collected, according to J. Baumberger's determination: *Cassidulus* cf. *ellipticus* and *Plesiolampas ovalis* (Ducan & Fladen, "Tertiary and Upper Cretaceous Fauna of Western India": Palæontologia Indica, 1883). The specimen *Plesiolampas* is embedded in clayey marls rich in *Assilina* and Nummulites.

These beds belong to the Eocene and perhaps correspond to the *Echinolampas* zone of Middlemiss.

The facies of the Upper Nummulitic in other parts of the Salt Range is of interest in regard to the extension of the oil-horizon. According to Lyman and to communications of natives tar occurs in the middle Salt Range in places which, according to Wynne's map,

must fall on the boundary between Nummulitic limestone and Murree sandstone.

In the eastern part of the Salt Range I had the opportunity in several places of studying specially the beds between the Nummulitic limestones below and the overlying sandstone formation. Near the hamlet of Mola, not far from Phadial, I observed the following section (Fig. 11).

Fig. 11.

The same beds are somewhat better developed in a brook north of the hamlet Lheri Saidan (Fig. 12) (*vide* topographical map, 1 inch = 1 mile, No. 43 H, District Jhelum). They probably represent the Upper Nummulitic. The strata dip to the north-west at about 20°. The nodular marls have exactly the same character as the corresponding bitumen-bearing beds of the region of Golra, Ratta Hotar, and Murree (Kuldana). They do not, however, bear bitumen here. In this as well as in the small thickness of the clayey formation between the Nummulitic limestone and the sandstones, the facies differs from that of the western Salt Range. Gypsum and cellular limestones are also absent.

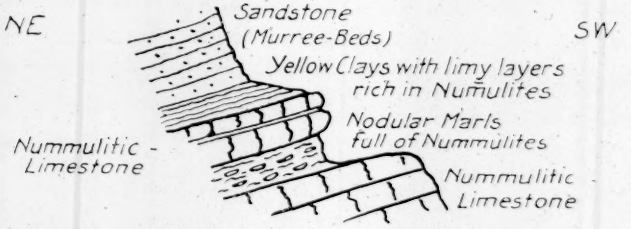


Fig. 12

Near Phadial, at the base of the sandstones, however, I have found the same giant oolite which, near Jaba in the western Salt Range, forms the rock overlying the oil-bearing beds. We find the giant oolites also in the middle Salt Range overlying the Nummulitic limestone. On the plateau south of Kallar Kahar (special map No. 43 D 9, Attock and Jhelum District) they are well exposed (*vide* Fig. 13). The giant oolite therefore marks a very

important stratigraphical horizon which almost throughout the whole Salt Range overlies the Nummulitic formation.

Tectonics.—The Sections I–IV on Fig. 10 show the most important tectonic features of the Jaba oilfields. From Massan towards the hills the inclination of the strata increases more and more. Near Massan the sandstones dip at about 10° only to the north-east, but their inclination increases to 50–60° at the border of the Salt Range. At the oil locality Chota Kutta itself the limestone beds dip 60°. (Section I, Fig. 10.)

The inclination of the oolitic beds overlying the oil rocks is exceptionally steep (*circa* 80°). At about 700 feet to the south-west of the oil-springs the north-eastern dip ceases and a steep south-western inclination of the beds takes its place. To the west, behind the limestone ridge where the valley of Chota Kutta becomes flatter, the Upper Nummulitic beds appear again as well as the Murree sandstones. Thus the first range of the hills forms a normal anticline, the core of which is the Nummulitic limestone ridge. The Upper Nummulitic beds, as well as the oil rocks, have been removed by erosion above the anticlinal axis, and are only preserved on the steep flanks.

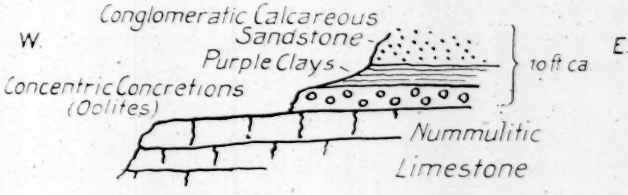


Fig. 13

Near the oil-spring Burra Kutta the first mountain range consists of two anticlines separated from one another by a shallow syncline (Section II, Fig. 10). The strata of the uppermost limestone beds from which the main oil-springs issue are nearly vertical or even overturned, dipping south-west. The overlying beds, however, are much less steep. Towards the hills the Nummulitic limestone beds form a well-curved arch. To the south-east, in the direction of the strike of the folds, the limestone dives below the Upper Nummulitic beds. This descending anticline is the direct continuation of the anticline A of the first section (Section I, Fig. 10). Both belong to the same fold, which may be recognized from the map (Fig. 9). But in Section II the crest of the anticlinal limestone core lies about 600 feet lower than in Section I—taking into account the masses removed by erosion. The axis of the anticline A (Sections I–III), therefore, dips at about 15° S.E. In Section II the main anticline is the anticline B. The axis of the anticline B

is inversely inclined to the north-west at rather a high angle, so that in Section I the anticline B has sunk completely underground. Its probable position in Section I is marked by a slight curve on the strata (on Fig. 10).

In Section III the dimensions of the two anticlines are still more different. The whole range is formed only by the anticline B, the anticline A having sunk completely underground.

Farther to the south-east the high ridge culminating at the point 3,060 feet (Fig. 9), is entirely formed by the limestone core of the anticline B.

In these—from the geological point of view—young folds of the western Salt Range the shape of the surface is in strict mutual relation with the geological structure of the ground. Thus, for instance, it can easily be observed from a distance of several miles that the axis of the anticline B inclines south-east towards the valley of the Majuchh Nala. I have therefore examined the outcrops of this valley, and indeed I found that the crest of the anticlinal limestone core rises only very little above the Majuchh Nala, and a few hundred metres farther to the south-east of the river the whole limestone arch is entirely covered by the Upper Nummulitic deposits. The pitch of the descending anticlinal axis is about 15°. (Figs. 9 and 10, Section IV.)

Higher up the Majuchh valley the Nummulitic limestone forms some flat folds and rises up over the older formations lying below. The Upper Nummulitic and the Murree beds are limited to the north-eastern exterior border of the hills.

From the description given above it follows that the predominating structure of the north-eastern border of the western Salt Range is a typical example of folding. There are several folds alternating in such a way that the folds lying more inside of the hills approach —striking south-east—the exterior border, while the folds of the border disappear from the surface descending below the ground level. The different anticlines appear distinctly as mountain ranges, and disappear from the surface owing to the pitching of the anticlinal axis.

(To be concluded.)

REVIEWS.

GEOLOGY OF INDIA FOR STUDENTS. By D. N. WADIA, M.A., B.Sc. pp. xx + 398, with 20 plates and 37 figures in the text. London: Macmillan & Co. 1919. Price 18*s.* net.

THE last edition of the *Manual of the Geology of India* appeared in 1893. Since that date Vredenburg's *Summary of the Geology of India* (1907) and Holland's article in the *Imperial Gazetteer of India* (1907) have been published; but both of these are brief, and Mr. Wadia, accordingly, deserves the gratitude of geologists at home as well as in India for giving us a volume on a scale commensurate with the importance of the subject. Unlike the *Manual* his book is not official; it is written as a textbook for University students, and, perhaps for this reason, it is easier to read and follow than most official publications. It is, indeed, so clear in style and arrangement that it may even arouse the attention of geologists who have been deterred by the difficulties of an unfamiliar nomenclature from studying the great problems of Indian geology.

Several of these are of universal interest. Few parts of the world offer conditions more favourable for the study of the "Fundamental Complex" than the Indian Peninsula, and though the Geological Surveys—of the native states as well as of the Indian Government—are compelled to devote their attention primarily to questions of economic importance, considerable progress has been made in recent years in the elucidation of its more important features. We now know that a large part of the Complex consists of intrusive masses, which in some cases are of later date than the beds which rest upon it.

But it is to the mountain ranges of the north that geologists in general look with the greatest interest. The contrast between Peninsular and extra-Peninsular India, both in structure and in the character of the deposits, was pointed out even in the first edition of the *Manual*, and later observations have only emphasized the difference. The researches of Middlemiss and others on the tectonics of the Himalayas and the other bordering ranges are of the greatest importance with regard to the general problem of mountain-building; and the question of isostatic compensation is of interest not only to the geologist but also to the geodesist.

Though a full discussion of such questions would be impossible and out of place in a textbook, Mr. Wadia gives an excellent summary of the present state of our knowledge of Indian geology, with references which will serve to guide the inquirer through the Memoirs and Records of the Geological Survey. Being himself a lecturer at the Prince of Wales' College at Jammu, in Kashmir, he has added a special appendix on the geology of that province, which, as he says, "contains one of the finest developments of the stratified record seen in the Indian region."

The book is admirably produced, and the use of heavy type for the headings of sections and the addition of sub-headings in the margin make it very easy to refer to. Illustrations are not numerous, but in addition to text-figures there are a dozen plates reproduced from photographs and a number of black and white maps of different regions. There is no general geological map, which would have necessitated the use of colour and would have greatly increased the cost of production; but since the map issued by the Geological Survey is available, it was certainly wise not to increase the expense of the book unnecessarily, and considering the circumstances the price has been kept remarkably low.

P. L.

Type Ammonites. By S. S. Buckman. Part XIX, August, 1919; XX, October, 1919; XXI, March, 1920; XXII, June, 1920. pp. 5–18, with 53 plates and a portrait. Published by the Author. Sold by W. Wesley & Son.

Part XIX begins vol. iii of this work, of which the title of the previous volumes is *Yorkshire Type Ammonites*. No indications are given as to whether the author contemplates limiting the scope of the work to the Jurassic Ammonites of the British Isles or giving it a more extensive stratigraphical and geographical range. Additional terminology is proposed, and the following generic names introduced: *Lamberticeras*, *Vertebriceras*, *Korythoceras*, *Pavloviceras*. The first of these names was found to be pre-occupied, and is replaced by *Bourkelamberticeras*. *Prionodoceras* is introduced in place of *Prionoceras*. In a section on "Development" the author says, "The early Orthocones utilising the gas effusion, which resulted from temporary indigestion under the nervous apprehension of danger, found that a cone thus made more buoyant was a help in rapid retreat from foes."

The Mineral Industry of the British Empire and Foreign Countries. Imperial Mineral Resources Bureau Digests. Chrome Ore and Chromium, 29 pp., 1*s*. net; Magnesite, 42 pp., 1*s*. 3*d*. net; Monazite, 15 pp., 6*d*. net; Felspar, 16 pp., 6*d*. net; Borates, 24 pp., 9*d*. net; Fuller's Earth, 15 pp., 6*d*. net; Nitrates, 28 pp., 9*d*. net; Arsenic, 19 pp., 6*d*. net; Bismuth, 14 pp., 6*d*. net; Asbestos, 34 pp., 1*s*. net. Stationery Office, 1920.

The ten pamphlets listed above are the advance guard of what is intended to be eventually an annual volume somewhat on the lines of that well-known American publication *The Mineral Industry*, containing information on the mineral resources of the world, with special reference to the British Empire and its needs. The present publications are to a great extent a review of the progress or otherwise of each industry during the War period, 1914–1919.

They do not profess to be complete monographs, but rather synopses of the information available for the period under review. The information given is largely statistical, but useful sections are included indicating the mode of occurrence and principal industrial applications of each mineral, together with in each case a bibliography of recent technical publications bearing on the subject: this is an excellent feature. The particulars given appear to be very accurate and up-to-date, and these small handbooks will be of great value to all concerned in the various industries. We shall anticipate the appearance of the complete volume with much interest. It is stated in the prefaces that in future great use will be made of graphic representation of statistics. We are inclined to regret this, as in our opinion such graphs have been overdone of late years. They take up a lot of room, and may be misleading unless all are on the same scale and refer to the same units, which is usually impossible.

Lorraine and Saar Minefields. Handbooks of the Historical Section, Foreign Office, No. 31. 30 pp. 1920. Price 1*s.* net.

THIS small pamphlet, one of a series prepared by the Foreign Office for the information of delegates to the Peace Conference, contains an excellent summary of the geography, geology, production, and reserves of the iron-mining district of Lorraine and Luxemburg and of the coalfield of the Sarre. The enormous importance of the minette of Lorraine as a factor in the iron and steel trade of Europe is well brought out, and the political aspect of the matter is clearly explained, as it stood before the terms of peace were settled. The somewhat inferior character of the Sarre coals, and their unsuitability for metallurgical coke, are rightly insisted on, and the difficulty of obtaining an adequate supply of coal and coke for France is discussed; it is suggested that the best solution is to be found in an extension of the canal system and improvement of existing waterways.

A Textbook of Geology. By Philip Lake, M.A., F.G.S., and R. H. Rastall, M.A., F.G.S. pp. xiv and 508. Third edition. 1920.

A COPY of the above textbook is recognized as part of the present-day equipment of every geological student, and its value and popularity are both proved by the welcome appearance of a revised third edition, that treads closely upon the heels of a second impression of the previous issue, reviewed in the February number of the Geological Magazine for 1911.

Whilst retaining in the main the well-arranged form and contents of the earlier editions, the present book has been thoroughly revised and enlarged. The section on coral reefs has been enriched by notes on the results of investigations of American geologists such

as Dana, Davis, and Daly, whose work affords strong support to Darwin's theory of submergence.

A chapter on ore deposits has been rewritten by Mr. Rastall. The study of ores is a branch of petrology, and a scientific classification of ore deposits must be based ultimately upon their mode of origin. We may recognize primary ores, vein deposits, cavity fillings, replacement deposits, and sedimentary ore deposits besides those formed by metamorphic action.

An interesting section on the history of igneous activity in the British Isles is also contributed by the above-named writer as a supplement to Mr. Lake's précis of the geological history of the British Isles. Earth movements and igneous activity are so closely interrelated that it is impossible to consider them apart. In an area like North Wales, for example, where post-Carboniferous movements are pronounced, it is important to realize that although no igneous rocks ascribed to that period are visible, such rocks may nevertheless underlie a large part of the district. A map of the chief folds and faults of Northern England and Wales is given in plate xxiv.

The classification of the Permo-Trias of Cumberland and the Vale of Eden does not appear to be satisfactory. In the first place gypseous shales and marls apparently occur in the top of the so-called Permian of the Vale of Eden, as well as in the bottom of the Trias. Again, no mention is made of the Keuper Kirklinton Sandstone, which is asserted by Professor J. W. Gregory to overlie directly the St. Bees Sandstone, not only of Northern and Western Cumberland, but also of the Isle of Man. These are minor details, however; a wider question is involved in the consideration whether any clear-cut division can be established between the so-called Permian and Trias in Western Cumberland.

As regards the general direction of travel of glacial erratics, it may be mentioned that a boulder of Shap Granite was found by the writer at Bledworth in Nottinghamshire, far south of the limits shown in the map, fig. 31.

The book is well illustrated, printed in clear, readable type, and furnished with a useful index.

B. S.

THE DATA OF GEOCHEMISTRY. By F. W. CLARKE. Fourth edition. Bulletin 695, U.S. Geol. Survey. 832 pp. 1920.

WE are glad to welcome the appearance of the fourth edition of this invaluable work, which exceeds its predecessor in size by about ten pages. In the absence of any prefatory remarks it is difficult to obtain any idea of the extent of the changes in a book of this size and nature, but a casual examination and an inspection of the footnotes and index show that a large amount of the most recent work has been noticed. This book has always been remarkable not only for the skill with which a vast amount of information has been compressed into a comparatively small space, but also for the

reasonable and common-sense attitude adopted in controversial questions. Many current subjects are discussed in an impartial manner, the arguments on both sides being fairly stated. As an example we may perhaps quote the temperate summary given on pp. 416–29 of the difficult problem of the classification of the igneous rocks, a subject which has of late attracted much attention on both sides of the Atlantic, and is admittedly as yet far from settled. The petrologist, mineralogist, and economic geologist will find in this book a mine of information on many little-known points of interest, together with voluminous references to original memoirs. By a rough computation the index contains nearly 7,000 headings, and there are few workers in any branch of geology who will not here find some new and valuable information often culled from the most recondite sources.

Special Reports on the Mineral Resources of Great Britain Vol. VII: Mineral Oil, Kimmeridge Oil-shale, Lignites, Jets, Cannel Coals, Natural Gas, England and Wales. Second edition. pp. iv + 125, with a plate and 7 text-figures. 1920 Price 5*s*. net.

THE second edition of this interesting and useful memoir has been enlarged and amplified by an account of the explorations lately going on for oil in Great Britain, brought up to the date of going to press. We note, however, with regret that this date is as far back as June, 1919. A map is given showing the position of the borings in the Chesterfield–Mansfield district, and their relation to the geological structure, together with a general section of the Carboniferous strata of Derbyshire, and a diagram showing the lie of the rocks along a line from Ashover past the Hardstoft boring. From this it is clear that the small accumulation of oil there was due to a roll in the strata combined with specially favourable local conditions. The total production up to October, 1919, was 849 barrels—a quantity which is of no practical significance as a commercial proposition, taking into account the cost of a 3,000 feet bore

A short account is also given of the work undertaken for the establishment of a Kimmeridge oil-shale industry in Norfolk, with a description of the strata encountered in various borings and shafts. Fossils have been recognized belonging to both Lower and Upper Kimmeridgian zones, and some horizons are richly fossiliferous.

An investigation of the cannel and other oil-yielding rocks has shown that cannels are of strictly local development, and the best seams are nearly exhausted. This does not seem to show any promise of being a future source of commercial oil-supply.

R. H. R.

Special Reports on the Mineral Resources of Great Britain. Vol. XIII: Iron Ores (contd.), Pre-Carboniferous and Carboniferous Bedded Ores of England and Wales. By Sir A. Strahan, W. Gibson, T. C. Cantrill, R. L. Sherlock, and H. Dewey. Mem. Geol. Survey. pp. iv + 123, with plates and 10 figures. 1920. Price 7*s.* 6*d.* net.

IT has long been a cherished conviction with writers of school geographies and similar books that the iron-mining industry of the British Isles is located in the coalfields. A careful study of this publication may perhaps help to disabuse them of that entirely out-of-date idea. It is here brought out clearly that the production of iron-ore from the Coal-measures is now of trifling importance, and though much smelting is still done in the coalfields, this is solely because of the presence of coal and not of iron-ore. As a matter of fact the output of Coal-measure ironstones is now about 8 per cent of the British total, and is declining yearly.

An interesting account is given of the deposits of iron-ore still worked spasmodically among the Lower Palæozoic rocks of North Wales; most of these are oolitic, often incorrectly called pisolitic, and far too rich in sulphur, since they appear to be formed largely by oxidation of pyrites or marcasite.

The blackband and clayband ironstones are still worked to some extent in North Staffordshire, and near Bradford, where the famous Low Moor iron is produced. In the other coalfields the industry is nearly extinct, though large reserves undoubtedly exist, especially in South Wales, where they are conservatively estimated at 5,000,000,000 tons. A great change in industrial conditions must occur before these become economically possible sources of iron on a large scale.

The Economic Geology of the Central Coalfield of Scotland, Area IV: Paisley, Barrhead, Renfrew, and the Western Suburbs of Glasgow. By L. W. Hinxman, E. M. Anderson, and R. G. Carruthers. Mem. Geol. Survey, Scotland. pp. iv + 110, with viii plates and 5 text-figures. 1920. Price 6*s.* net.

THIS volume contains a detailed account of the economic geology of the western part of the Central Coalfield; the area dealt with includes, south of the Clyde, the districts of Thornliebank, Hurlet, Barrhead, Paisley, Johnstone, Renfrew, and Ibrox, while north of the river it extends from the suburbs of Glasgow to Duntocher, Milngavie, and the Kelvin valley above Balmore. The method of treatment is similar to that adopted in the four volumes of the series that have already appeared. The Coal-measures in the strict sense cover very little ground in this area, but the coal and ironstones of the Carboniferous Limestone Series have been extensively worked in the past and are by no means exhausted, especially south of the Clyde.

The volume also contains somewhat detailed accounts of two special features of much interest, the Paisley Ruck and the Thick Coal of Quarrelton. The Paisley Ruck, although a leading tectonic feature, appears not to have been hitherto described. It is essentially a crush-zone or shatter-belt, of generally anticlinal form, beginning on the north side of the Clyde near Drumchapel, and extending south-westwards, past Paisley and Johnstone, and through the Lochwinnoch gap into Ayrshire. Within this zone, which is from 150 to 200 yards broad, the strata are extraordinarily broken and contorted, while the edges are as a rule sharply defined by faults with varying displacement. Near Linwood the throw of the fault on the northern side is at least 1,800 feet, though usually much less.

The Thick Coal of Quarrelton appears to be formed by the local coalescence of several seams, and has a normal thickness of nearly 50 feet. But there are also at least two cases of local "doubling"; in one of these the enormous thickness of 100 feet of coal, or coal with thin clay partings, is attained. It is shown that the thick seam was originally laid down against a steep slope of the underlying lavas, and that the duplication was caused, not by overthrusting but by a contemporaneous process analogous to a bog-slide. This fact seems to have some bearing on current discussions as to the origin of "wash-outs" in other coalfields.

R. H. R.

Die Sulfid-Silikatschmelzlösungen, I: Die Sulfid-schmelzen und die Sulfid-silikatschmelzen. By J. H. L. Vogt. Videnskr. Selsk. Skrifter, I Mat.-nat. Klasse, 1918, No. 1. 132 pp., with 45 text-figures. Kristiania, 1919.

Die Sulfid-Silikatschmelzlösungen. By J. H. L. Vogt. Norsk. Geol. Tidsskr., vol. iv. 97 pp., with 13 text-figures. Kristiania, 1917.

THESE two publications contain the results of researches undertaken by Professor Vogt during the last few years on the physical chemistry and mineralogy of the sulphides and their relations to silicate melts, with special reference to the slags obtained in the smelting of copper matte. The first-named and larger work forms a third part of Professor Vogt's well-known work *Die Silikatschmelzlösungen*; the second contains a summary of the results set forth in the larger volume, published at an earlier date owing to difficulties encountered on the production of the complete work under war conditions. We are also informed in a preface that another memoir is in preparation dealing specially with the nickeliferous pyrrhotite ore-bodies, which are here only referred to incidentally. The publication of this will be anticipated with much interest by all mining geologists. Professor Vogt also states that he has in hand a nearly completed work on crystallization and magmatic differentiation in the basic intrusive rocks.

The facts here set forth are of the greatest possible interest, both in their technical applications to furnace practice and in their bearing on theoretical petrology and the genesis of the sulphide ores. It is now generally accepted that silicate melts of whatever composition are completely miscible in all proportions, but with regard to the relations between fused silicates and sulphides the conditions are quite otherwise. Silicate and sulphide melts, as well as silicates and molten metals, possess only very limited mutual solubilities, and in the fused state must form systems of two liquid phases. This proposition is, in fact, self-evident, since it forms the foundation of all smelting processes. Pig-iron and slag separate in the blast-furnace, not because the molten iron is heavier than the slag, but because the two liquids are mutually insoluble at the furnace temperature, and the same applies to the separation of sulphide and slag in copper matte smelting. In both these processes it is obviously desirable to have the cleanest possible separation of metal or sulphide and slag, and it is the investigation of the conditions most favourable to this clean separation that is the chief object of Professor Vogt's researches.

In the first place, it is evidently desirable that the slag should be as liquid as possible, partly in order that it can be drawn off easily and partly to facilitate the sinking of globules of sulphide, which might otherwise remain entangled in a viscous slag. This can be obtained partly by employment of a very high furnace temperature, which is undesirable from the point of view of fuel consumption and running costs. It is found, however, that the viscosity of the slag is very clearly a function of its chemical composition, and especially of its silica percentage. This also has a very important bearing on the solubility of sulphide in slag; this solubility varies inversely as the silica percentage, and directly as the temperature. Very basic slags at a high temperature cause the greatest losses of copper in matte-smelting, and this loss is apparently increased by the presence of much zinc. The practical problem is therefore to find the best working conditions, so that the two opposed factors may compensate each other. The loss of copper inevitable with a liquid basic slag in which the solubility is high has to be balanced against the loss of copper in a viscous acid slag with low solubility, but with a strong tendency to mechanical retention of sulphide. This is a nice example of the application of mineralogy and petrology to problems of the highest practical importance, a point of view which appears to be scarcely appreciated by British petrologists.

Rather more than half of the smaller work here reviewed is devoted to a discussion of the nickeliferous sulphide segregations and their relation to the norites. This is presumably a summary of the forthcoming larger publication before mentioned. It is shown that nickeliferous sulphides have a strong tendency to occur along with rocks rich in rhombic pyroxenes, which are mainly magnesia-iron

silicates, rather than with the more calcareous diopside-rocks or normal gabbros. A few sulphide masses of this type are found along with olivine rocks, especially peridotites. The physical chemistry and equilibria of the norite magmas are discussed, and it is shown that many of them approximate closely to eutectic composition (anchieutectic rocks). Most of the great pyrrhotite deposits are associated with norites that contain more hypersthene than corresponds to the eutectic limit between labradorite and hypersthene; where felspar is in excess sulphide segregations are much less common. In the cases described it is quite clear that the pyrrhotite crystallized later than the pyroxenes, olivine, and felspars. Incidentally it is of interest that, however quickly cooled, sulphides are always completely crystalline; no such thing as sulphide glass is known to exist. This behaviour is in strong contrast to that of the silicates. Likewise, it appears that owing to the highly mobile nature of fused sulphides, under-cooling does not occur to any appreciable extent, but sulphides crystallize sharply close to their true freezing-point.

All the phenomena attending the occurrence and crystallization of the sulphide segregations and their consanguineous silicate rocks become easily intelligible when it is once fully realized that silicates and sulphides possess very limited mutual solubility, and at the normal temperature of intrusion must of necessity form two liquid phases; this conception greatly helps in the solution of the problem of the genesis of the great nickel deposits of Sudbury and others, a problem which has of late years led to so much discussion by many petrologists, both from its inherent interest and from its great technical importance.

R. H. R.

REPORTS AND PROCEEDINGS.

Royal Geological Society of Cornwall.

November 14, 1920.

"On the Geology of St. Michael's Mount." By E. H. Davison, B.Sc., F.G.S.

The granite of the island is not of normal character, but shows idiomorphic crystals of quartz and felspar in a fine-grained crystalline ground-mass. The predominant type of alteration is greisening, the granite being traversed by a series of narrow parallel veins of greisen, with a central portion of pegmatite or of quartz, which carries such minerals as cassiterite, blende, wolfram, chalcopyrite, molybdenite, apatite, lithia mica, fluor, tourmaline, beryl, etc. The slate in contact with the granite shows evidence of intense thermal metamorphism, and in some cases there is evidence of the granite having absorbed the slate along the contact. Impregnation of the slate by minute granitic veins is also common. The lodes are seen in the form of greisen veins carrying mineral and in the form of more typical fissure lodes, and they occur in great numbers in both granite and clay-slate, but are all narrow. A clean ferruginous sand occurs in the island, which in many respects resembles St. Erth Sand. Tourmalinization is the exception, and the author concludes that the veins were filled by magmatic solutions which were highly siliceous and contained fluorine to a considerable extent, but little boron.

"Note on an Alluvial Pebble from Nanpuska." By E. H. Davison, B.Sc., F.G.S.

The special interest of the pebble lies in the relationship of the quartz and cassiterite. The pebble is triangular, the apex being formed of a small mass of dark-brown zonal cassiterite, with quartz above, through which needles of cassiterite are arranged radially. The microscope shows the quartz to be a mosaic, and the quartz and cassiterite needles must either have crystallized simultaneously or the needles crystallized in a solution of silica sufficiently viscous to hold them in position.

"Note on an occurrence of Granite at Bridge." By E. H. Davison, B.Sc., F.G.S.

In a quarry at Bridge, $1\frac{3}{4}$ miles north of the margin of the Carn Menelez granite, a quartz porphyry dyke was seen to contain a large xenolith of granite just above the foot wall. The granite showed no signs of having been melted along its margin, and seems to have been carried but a short distance. This confirms the view that the slope of the Carn Menelez granite mass to the north is very gentle.

"The Geology of Killifreth Mine." By H. Kitto.

A detailed description of the geology of the mine and the lode characters. The country rock is mostly slate, but a quartz porphyry dyke is cut in two levels, and a tongue of granite is met with about 40 fathoms from surface and a tongue of schorl rock nearer surface. The minerals of the lodes include cassiterite, wolfram, mispickel, pyrite, blende, molybdenite, and smaltite. Several of the lodes show filling in two distinct stages, and the values are high but patchy. The author discusses an interesting case of a lateral fault without vertical displacement.

"The Geology of Carn Marth." By G. MacPherson.

The geology of the district round Carn Marth is described with special reference to the igneous rocks. The so-called differentiated granite of the top of Carn Marth is considered by the author to be three successive intrusions of different types of granite; first the coarse-grained type, second the fine-grained granite without tourmalinization, third the tourmalinized fine-grained granite. Pegmatite and aplite veins also occur in the granite.

Yorkshire Naturalists' Union.

December 4, 1920.—At Bradford.

Presidential Address by Professor J. E. Marr, Sc.D., F.R.S.

Professor Marr dealt with the tract of country comprising north-west Yorkshire and parts of the country lying to the north, where Carboniferous rocks are nearly horizontal over a wide area. He maintained that this tract had formed a rigid block of earth's crust, certainly since the beginning of Carboniferous times, and possibly for a longer period. Referring to Mr. R. H. Rastall's work on the Ingletonian rocks, which contain fragments of crystalline schists, he argued that a core of ancient rocks lay under the Carboniferous strata, and that newer rocks had been folded against this core at various times on the south, west, and north. The rigid block is bounded on the west and south by the Pennine, Dent, and Craven faults, and he gave reason for supposing that as movement went on against the block at different times, parts of the compressed rocks were added to the rigid block, causing it to grow outwards, the newer fault-lines lying further away from the centre of the block than the older ones. He supported this by special reference to the tract of Edenside, west of the Crossfell portion of the Pennine Chain, where there appeared to be evidence of faulting at the end of Carboniferous times, subsequently in Permo-Triassic times, and later still possibly in the Tertiary era. Similar changes seemed to have occurred to the south, along the Craven system of fractures. There was, however, some difference in the nature of the earth-waves affecting the areas to the west and south of the rigid mass. The former were comparable with the great rollers of the ocean, those of the latter rather

with the conflicting waves of a choppy sea. Were, he asked, the smallest of these of the nature of eddies swirling on the larger waves? There was a reference to the origin of Mr. Tiddeman's "reef-knolls", the mystery of which would, he hoped, be cleared up by Yorkshire geologists.

The address concluded by referring to various matters geological and physiographical, and concluded with the geographical distribution of organisms which were more or less dependent upon the character of the rigid block.

Edinburgh Geological Society.

Mr. E. B. Bailey, M.C., B.A., F.G.S., F.R.S.E., President, in the chair.

1. "A new Volcanic Vent and other new Geological Features on the Shore, Weak Law, Gullane." By T. Cuthbert Day, F.C.S., F.R.S.E.

The place referred to is a wild, rocky stretch of coast, about half a mile in extent, a little to the west of the Island and lighthouse of Fidra. The author demonstrated by means of a map and lantern views the geological structure of the shore. Summing up the work commenced in 1914 and continued in 1919 and 1920, he sought to establish the presence on the shore at Weak Law of the following features:—(1) A considerable fault running along the shore from S.W. to N.E. with a downthrow to the N.W. of 200 feet or more. This fault brings down the Carboniferous shales of a considerably higher horizon to the level of the lowest bed on the shore, which is a nearly horizontal flow of a very vesicular trachyte lava. This lava is itself visibly overlaid by trachyte tuff and trachyte lavas to the height of 50 feet at least in the cliffs. (2) A great mass of intrusive igneous material, the matrix of which appears to be composed of white trap; the whole intrusion is highly charged with fragments and blocks, particularly of shale and ironstone. This intrusive mass fills the line of fault, cementing itself to both sides, and sending extensive tongues into the trachytes of the shore. (3) A sill of white trap in the shales, near low-water mark, and connected with the main intrusion. (4) A small intrusive boss of trachyte piercing the trachyte lava of the shore. It is of different material to that of the lava, being very compact and showing many decomposed phenocrysts of sanidine and a great number of scattered granules of augite. (5) A volcanic vent, about 230 yards in diameter, breaking through the older trachyte rocks of the shore, and itself subsequently truncated by the fault before-mentioned, and invaded by the intrusion filling that fault. The presence of this vent was shown by the following evidence: A boundary-line can very readily be traced; the lavas and tuffs outside the boundary dip inwards towards the vent. The ash within the vent is everywhere essentially different to that found outside, a characteristic feature being that it is highly charged with dolomite

and ferrous carbonate. Buried within the ash filling the vent are great masses of a rock composed of a sandy, dolomitic clay, of a nature not occurring on the shore in the immediate neighbourhood, and evidently belonging to a higher horizon. It is manifest also that the cliffs themselves have been breached by the vent, and a large, nearly semicircular recess has thus been produced. In the ash of the vent numerous blocks and bombs of trachyte were found. (6) The remains of a bed of very coarse conglomerate which lies unconformably across the outcrop of shales at low-water mark. This bed is apparently of very modern origin, and points to a time when the land was somewhat higher, and probably covered with sand dunes having many pebbles and rocky fragments at their base. These have been cemented in a sandy matrix, all bound together by carbonate of lime derived from the water which has filtered down through the sand dunes. (7) A peculiar structure in the rocks on the shore; it is of some size, and is bounded by a semicircular fault with a hade inwards of 30 to 45 degrees. It resembles a ring fracture of the strata caused by the sudden subsidence of a limited area.

2. "An Exhibit of Maps and Memoirs of Anglesea, by Edward Greenly, F.G.S." By the President.

GEOLOGISTS' ASSOCIATION.

Friday, January 7, 1921.

"The Post-Pliocene Non-marine Mollusca of the East of England." By A. S. Kennard, F.G.S., and B. B. Woodward, F.L.S., F.G.S.

This paper deals with the non-marine mollusca of the Pleistocene and Holocene deposits of the counties of Suffolk, Cambridge, Northampton, Huntingdon, Hertford, Bedford, and Norfolk (except the Forest Bed).

Sixty-five localities are dealt with, thirteen being new, whilst a large amount of fresh material has enabled the authors to make many additions and corrections to the previously published lists. Notes on some of the more important species are given.

The authors are of opinion that the evidence furnished by these deposits fully supports their previously expressed views as to the sequence of events in the Pleistocene period, viz, that there has been one glacial period only, and that it occurred at the end of the Pleistocene.

CORRESPONDENCE.

GEOLOGY OF THE NINGI HILLS.

SIR,—I hasten to express my regret that I did not mention the fact that in 1911 Dr. Falconer mapped the Ningi–Kila–Fagam granites. I am afraid that I am so familiar with and indebted to "The Geology and Geography of Northern Nigeria" that I forgot that others might not be equally acquainted with it.

I do not understand what is meant by "local controversies". So far as I know Dr. Falconer is the only geologist who has written anything on the geology of this area, and also I do not see how these preliminary notes, based on a prospector's notebook, can be regarded as controversial. It would have been better, I admit, to have retained Dr. Falconer's non-committal nomenclature of the "younger granites", at any rate pending further research.

It is, however, difficult to follow the rest of the letter. In the map that accompanies Dr. Falconer's book the area covered by my traverse is, with the exception of the Ningi, Kila, and Fagam Hills, entirely mapped as ancient crystalline rock, as part of the great mass of archæan rocks that form the basal plain of Northern Nigeria. I have not the book by me at present, as I am on trek, but I am almost certain that, as shown on the map, Dr. Falconer's itinerary passed up from Sabon Garri, through Tipchi, and thence to the Ningi Hills. It passes therefore over the area I mapped as Sabon Garri granites, and along the same rocks in the shadow of the great mass of Duchin Chanya Cherigi.

It was on this authority that I classed these granites as archæan, for in all respects they correspond with the archæan granites described in the book, notably in that they show ill-defined margins with the gneisses and never, like the "younger granites", show any contact alterations. If, then, my Sabon Garri granites are merely "a number of outcrops of younger riebeckite granite projecting through older micaceous gneisses of various types", they should, according to Dr. Falconer, be accompanied by well-defined contact alterations. But there is no sign of such alteration, and though Nos. 100 and 105 were taken close to the edge of the mass and near to the schists and gneisses, they show no sign of marginal cooling. No one looking at these rocks and those of the Ningi granite could fail to note the marked difference in structure.

Moreover, these Sabon Garri granites may be traced across the Minna River and up to Ningi. Two miles north of that village there is an excellent contact between the Sabon Garri and the Ningi granite. The latter displays chilled margins and the usual contact phenomena.

I fear that the "capable observers who repeatedly traversed"

this area were ignorant of Dr. Falconer's own definitions of the two types of granite.

Finally, as the district was traversed in 1911, why are not these Sabon Garri granites mapped as "projections of younger granite"? They cover a larger area than the Kila granites, which are correctly mapped! Can it be that since Dr. Falconer adopted the theory (*vide* last paragraph in his letter) that tin occurs only in the younger granites, and since the presence of tin *in situ* in the Sabon Garri granites is unquestioned, he has rechristened these rocks to suit the theory?

It is easy to say in what rocks a given mineral does occur, but he would be a foolish man who asserts in what rocks it will not occur. Mineral occurrences are not confined to one age, and Murchison's classic error in regard to the occurrence of gold should not be forgotten. This is a matter of considerable importance. If tin is found only in the "younger granites", then it would be idle to look for it in any of the other rocks, so that, *vide* Dr. Falconer's map, only a very small area offers any prospects for the miner.

When I found tin occurring in granites which agreed with Dr. Falconer's description of the archæan granites associated with the gneisses (and mapped as such by him), I traced one series of these rocks and differentiated them from the normal non-stanniferous type under the name of the Sabon Garri granite.

Believing in the importance of this observation I published it, hoping that other mining men would come forward and describe the country with which they were familiar. By so doing the slight knowledge we have of the stanniferous granites would be widened. Nigeria is a large country, and vastly important as Dr. Falconer's work has been, it is only an outline of the geology of the Protectorate. The details, if they are to be filled in, must be done by the men on the spot who bring forward their notebooks and samples. The mining man is usually fitted to do this work. As a class unacademic in training or thought we make academic errors unconsciously. Witness the premature description of the "younger" granites as Mesozoic in my own "Notes". But on the whole the mining engineer who has preserved his interest in geology makes a good "unskilled labourer" in the field of geology, capable of recording observations and bringing home samples for the benefit of those whose knowledge is infinitely greater but whose opportunities of travel are vastly less. It is in that capacity that I regard my own work, a record of things seen, but not in any way an attempt to raise controversies.

I am sure that the Curator of the Sedgwick Museum would gladly give Dr. Falconer access to any of the slides or specimens so that he may see for himself the types of rock described, especially Nos. 100 and 105.

GERARD W. WILLIAMS.

P.O. Jos.
November 27, 1920.